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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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THE INSTITUTION OF MECHANICAL ENGINEERS.

The first ordinary general meeting of the above Institution for the Session 1916-17 was held on Friday last, the 20th inst., at the Institution of Civil Engineers, the chair being occupied by the president, Dr. W. C. Unwin, F.R.S.

Dr. Unwin opened the proceedings by referring to the losses by death which the Institution had recently suffered. Since the last meeting there had passed away Sir Frederick H. Donaldson, a past-president, the Chief Superintendent of the Royal Ordnance Factories, and with him Mr. Leslie S. Robertson, who had from its foundation been the secretary to the Engineering Standards Committee, and to whom the success of that committee was largely due. The Institution had also lost a very old member in the person of Mr. Price-Williams, upon whom, in recognition of his long services to engineering, the Institution had in the last session conferred an honorary membership. The Council had already conveyed to the relatives of the gentlemen named an expression of their sympathy and of the sympathy of the members generally, together with an appreciation of the great services which each of those deceased members had rendered to the profession. Dr. Unwin desired also to pay a tribute to the 29 members who had fallen in the service of their country during the present war. The names of these members were read by the secretary.

The formal business of the meeting having been transacted, Dr. Unwin then delivered a short and interesting address, which we print in full on page 425 of the present issue.

Trials on a Diesel Engine.

The paper set down for reading and discussion was one entitled "Trials on a Diesel Engine, and Application of Energy Diagram to obtain Heat Balance," by the late F. Trevor Wilkins (Northumberland Fusiliers), M.Sc. of the University of Birmingham. This paper we print in full on page 422 of the present issue.

Professor W. F. Burstall, in introducing the paper, stated that on hearing of Lieutenant Wilkins' death he had immediately volunteered to read the paper, and he derived great pleasure from so doing, if only as a slight testimony to the value of a piece of work of which, in his view, any man, however eminent, might be proud. Lieutenant Wilkins was a young man of exceptional powers, who had taken up the subject of internal combustion engines with the greatest ardour in quite his early days and had persevered with it since his graduation. At the time when war broke out Lieutenant Wilkins occupied a position with Messrs. Vickers at Barrow, which he subsequently quitted to join the Northumberland Fusiliers. Professor Burstall then went on to recount the history of the paper. Some five or six years before the author's tests a number of experiments had been made on the Diesel motor when it was a comparative novelty. These experiments, an account of which was published by the Institution of Civil Engineers, were far from complete, and the chief source of failure was in the practical impossibility of obtaining a reliable indicator diagram. The high compression, combined with the very small clearance space, made the loss on the compression stroke quite a serious matter. When the late Lieutenant Wilkins had been elected to a research scholarship, the speaker had suggested to him the possibility of tackling the Diesel motor in something like a scientific spirit. The first point of importance was the indicator illustrated in the paper. There was no pretence that it was a perfect indicator, but the speaker regarded it as possessing the elements of the finest optical indicator that could be constructed. The indicator under discussion had certain points and advantages not appearing in any other. Firstly, it was a diaphragm indicator, the pressure being recorded by the deflection of a thin corrugated diaphragm, which transmitted the motion to a mirror system. This form of indicator was liable to two grave defects, the first due to the variation of temperature altering the scale to an unknown extent. That was overcome by using two diaphragms linked together in the middle, and keeping the diaphragms at a constant temperature by passing a jet of steam between them; this plan removed all doubt as to the scale of the diaphragms.

Notwithstanding that Lieutenant Wilkins had said very little about the indicator he had devoted an enormous amount of attention to it, because very serious difficulties arose directly the instrument was got to work. The first was the hysteresis error, dimly shown on the diagram, Fig. 3, in the paper. The scale on rising and falling was not exactly the same. This difficulty was surmounted by experimenting with diaphragms of different materials. The materials tried included very pure charcoal iron, 0.2 per cent. carbon steel, up to high carbon steel, nickel steel, nickel chromes, and a variety of other things, in order to get a diaphragm in which hysteresis would be at the minimum, and which would stand. It was easy, when working with pressures of 600 lb. and 800 lb. to the square inch, to perforate the diaphragms completely. Eventually a nickel chrome steel, which was pressed out, was employed successfully. The diaphragms had to be pressed out with a special die, and although the difficulty was overcome to a large extent the hysteresis error was never entirely obviated. The main cause of such error was unquestionably the method of fixing the diaphragms into the indicator, the idea, of course, being to fix the sides rigidly to the body of the indicator so as to prevent motion; this was done by a nut, forced into position by a hydraulic press. The device, however, did not prove satisfactory, and if he (the speaker) were constructing such an instrument again, he would endeavour to join the diaphragms to a comparatively heavy steel body by acetylene or electric welding; nothing short of that would be of service. Those who had only seen a comparatively small indicator diagram would be surprised to see these, taken some 4 in. in length and nearly 3 in. high, where 60 diagrams would be represented on one plate with perfect precision. So far as the set of experiments under consideration was concerned, he was quite certain that they represented the most accurate indicating of a Diesel engine that had ever been done.

Professor Burstall went on to say that the whole gist of the paper lay in the study of this indicator diagram. The remainder of the quantities were all measured. The air suction, for instance, was measured through a meter, and precautions which would readily suggest themselves were taken to ensure accuracy. He would be content, therefore, to draw attention to some of the results. For instance, the injection air and the main air were both measured. Three sets of tests were made, the three quoted in the paper being only those selected out of a number, and were called "half," "three-quarter," and "full" load. Inquiry might be made as to the meaning of the term "full load," and it might be as well if he touched upon the point. Of course he referred to the true full load, and not the full load as represented by the makers of internal combustion engines. On taking a charge of combustible—petrol, heavy oils, either aromatics or paraffins, or a gas of any description—and mixing it with air, the explosion pressure produced would vary with the richness of the mixture. It was possible to go on increasing this until such a charge was reached as, when ignited, left over little or no free oxygen. That was the speaker's definition of a full load. Such a condition had no existence in practice; an attempt to run either a gas or an oil engine with anything approaching as little as 2 per cent. of free oxygen in the exhaust would prove impracticable, particularly with the oil engine; in the case of gas it was possible, for obvious reasons, to run more closely. With oil—and by "oil" he meant simply paraffin—there must be an excess of air; there must be something like 5 per cent. of free oxygen in the exhaust after combustion in order to produce what was called full load. If more oil were put in, it would not be burnt, but give rise to a smoky deposit frequently found in oil engines. The full load in the case of the engine considered represented the maximum amount of oil which could be put into that engine with an increase in the effective pressure on the indicator diagram. For himself, he would have preferred to call the full load in this case the "overload," and the three-quarter load the "full load;" and looked at from that point of view the results would better accord with expectation.

The speaker had no further information in relation to the paper than that which it contained, but he believed that, as he was so much in contact with the experiments when carried out, he could enlarge upon some of the points brought forward. He would refer members to Figs. 3, 4 and 5 of the paper, showing indicator diagrams. They would repay study because they exhibited the whole of the temperatures, which, taken from an accurate indicator diagram, told the entire story of the Diesel motor without further explanation. Taking the three-quarter diagram and looking at the jagged point at the top, something like constant-pressure burning would be observed, with a more or less isothermal curve; not quite an equal temperature curve, yet not differing widely from it. The speaker had himself stated, more than twelve years ago, that combustion was complete at maximum temperature, and all his experiments had pointed in that direction. Slaby, whose work was extremely accurate, had come to the same conclusion. It had to be admitted, however, that this conclusion was wrong, and combustion was not of necessity complete at maximum temperature. It was possible to have a certain amount of persistence of burning while the temperature varied very little. When, three years ago, the speaker had got out an energy diagram, for a readier computation of internal combustion engine problems, he had been curious enough to plot on to that diagram some of his own experimental results with gas engines, and had found that, as shown in the paper, there was a persistence of burning and of highest temperature. Observation of the three-quarters load diagram showed that the temperature rose from 900 deg. to nearly 1,200 deg. down the expansion line. It would be unfair to dogmatise, since oil did not burn like gas, and some of the effect might be due to the extreme difficulty of burning paraffin even in a Diesel motor. Undoubtedly the phenomenon was to a certain extent found in all motors of the type, and the plotting of it on to the energy diagram would mainly interest those who could investigate the matter in their own studies. Certainly, by this means, the interchanges of heat that took place were brought out in a very simple manner. They could, of course, be shown otherwise, as appeared from Fig. 6 in the paper, which exhibited the deviations between the theoretical cycle and the modification of the principle adopted in practice. It was, there, a curious fact that the second portion of the expansion line accurately coincided with the theoretical curves drawn from the specific heats of nitrogen. Whether that coincidence was accidental or not, Professor Burstall could not say; but in almost all cases it was borne out that, the more accurate the indicating, the nearer was the approach to the true equation of an adiabatic curve when the specific heat was taken as variable. The author had stated: "At present the opinion would appear to be that after-burning persists right down the expansion stroke. The figures obtained from these diagrams show that at full load there is distinct after-burning in the second quarter of the stroke, but that in the last part more heat is passing from the discharge to the walls than is supplied by after-burning. At half load the heat which has gone to the cylinder wall, when the piston is at the top of its stroke, is almost all repaid half-way down the expansion stroke."

Commenting hereon, Professor Burstall considered that these results might be quite innocently misinterpreted. To begin with, the engine was very small, the diameter of the cylinder being 6½ in. and the stroke 11 in., and in engines in which the volume was small in proportion to the surfaces exposed it was easy to obtain phenomena which did not accurately reproduce themselves when the size of the engine increased. The speaker was unaware of any work in which more mistakes could be introduced than in interpreting the tests of internal combustion engines. He had himself tested engines up to 49 in. diameter and 55 in. stroke, with, usually, the following result. After 19 in. diameter there was little variation. Between the diameters of 12 in. and 19 in.—he had not for a considerable time dealt with less than 12 in.—there were very great variations, according to the diameter of the cylinder and the formation of the breech end—whether the breech end were symmetrical or whether it had pockets. Results would be obtained which looked right in the case of one engine; with the next engine these results might

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(*For Description, see Page* 405.)

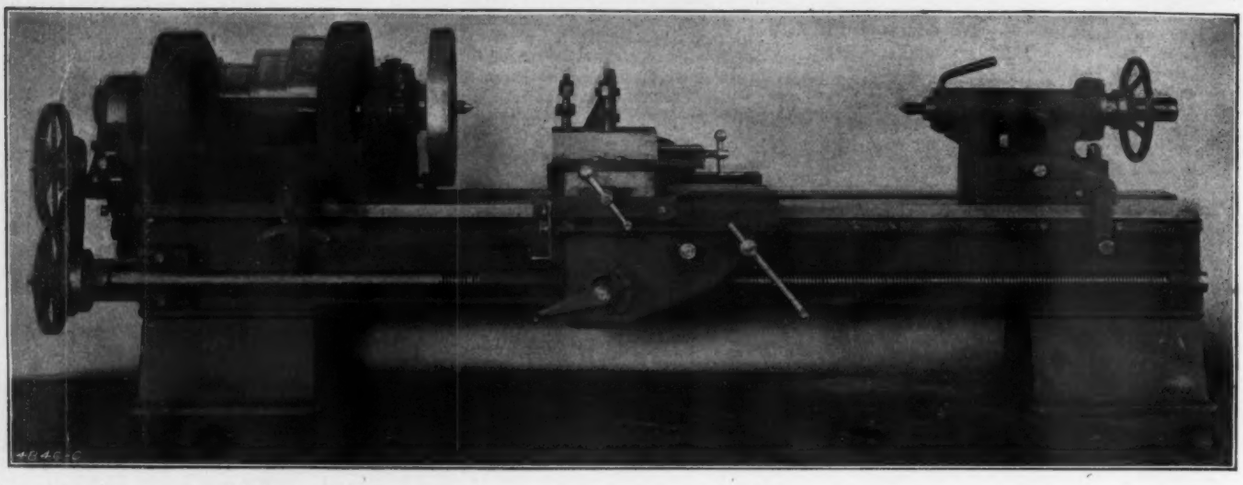
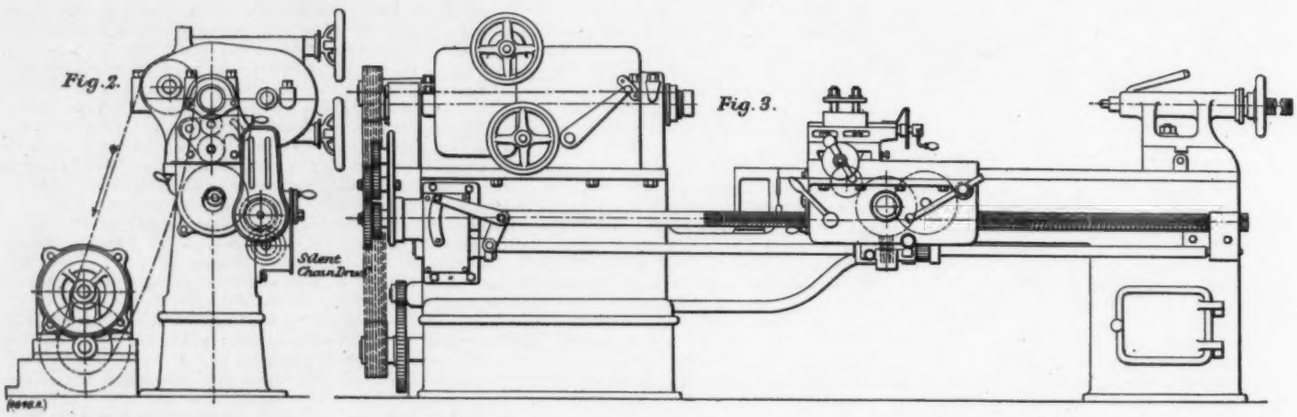


Fig. 1.



be totally reversed. He did not think it was wise, therefore, to lay down anything conclusive as to after-burning. It was certainly as stated by the author in the case of the engine tested, but with an engine of 14 in. or 15 in. cylinder diameter quite different phenomena might appear. Further, there was the question of fuel, which in Diesel engines was one of great importance. To be candid, he did not believe himself in the Diesel engine, though his personal opinion had nothing to do with the question.

The hydrocarbon oils fell under two heads, the paraffins and the aromatics. In the ordinary petroleum of commerce the aromatics were practically absent, and there remained a series of paraffins (in which the hexanes and pentanes had been removed right up to the octanes) and the oils which boiled at anything from 180 deg. C. to the neighbourhood of 240 deg. C.—much the same boiling points with aromatics. But in the aromatics there was an element of carbon, which was, so to speak, hanging loosely on to its neighbouring hydrogen element. On the slightest provocation the carbon element would shake itself free and deposit in the form of carbon. All the difficulty, from the time of Priestman and earlier, was to reduce the oil to a sufficiently fine state of subdivision to enable burning to be carried out, anything like completely, in the very short time allowable in any cycle of the internal combustion engine.

The matter might, Professor Burstall said, be put in another way, for better realisation of the difficulties. He would take hydrogen and methane as generally representative of gas. When these were in

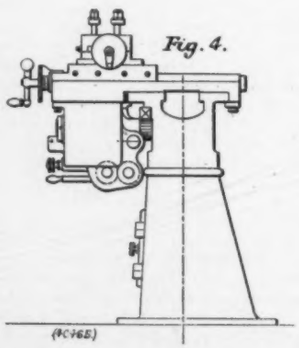


Fig. 4.

the cylinder and compressed, each element was more or less surrounded by plenty of oxygen elements, and the moment the ignition flame started the combustion was readily effected, because the gas was so intimately mixed up with the oxygen. With an oil of a paraffin or aromatic character, subdivided, as in the Diesel engine, by the injection of air at high pressure, the molecule of oil was reduced to a comparatively minute size, difficult to estimate —perhaps $\frac{1}{3000}$ in. in diameter. Although the atmosphere in which this occurred was very hot (500 deg. C. or above), in spite of the presence of free oxygen the rate of combination between the two was not anything like as rapid as where the two were gases. The result was that only the outer skin of the oil element was burnt. If the sphere of oil were sufficiently small it could be completely burnt, but in most cases it would not be sufficiently small, and the temperature range would finish with a certain amount of the oil substances still left in the exhaust product. Then the question arose as to whether on analysis of the exhaust gases free CO were found, indicating incomplete combustion. But free CO was not found, and, moreover, did not afford a criterion of incomplete combustion.

The only way of dealing with this point, and an extremely interesting way, was to pump a portion of the exhaust gas from the exhaust pipe into a vessel immersed in liquid air and freeze the whole of the exhaust content. With care, the nitrogen and oxygen could be passed away and the unburnt stuff could be trapped—carbon monoxide (it was nearly always the higher hydrocarbons that came down in this form), marsh gas, and those combinations generally given as in the neighbourhood of 3's, 6's, 8's and 7's; these could always be found in the exhaust of a Diesel motor. Professor Burstall had alluded to the point, inasmuch as it would be regrettable if anyone generalised upon the statement in the paper and found it not strictly true; it was a correct statement for the engine tested, but not for all Diesel motors. It might perhaps be safely said that there was a certain amount of combustion taking place during the first portion of the stroke, but during the second portion it was a matter of the nature of the oil. If

an attempt were made to burn aromatics (tar oils) the trouble was infinitely increased, because the carbon was free and was not joined to the hydrogen element; there would, accordingly, be the greatest difficulty in burning it at all. His experiments with the burning of aromatics left him little hope with regard to their commercial outlook.

Turning to another point. The extraordinary efficiencies proved in the second part of Table VI in the paper were very interesting. The figures of test results for half load were 44.5 per cent., for three-quarter load 43.8 per cent., and for full load 42.1 per cent. These results were not novel. Nevertheless they afforded proof that a heat motor could be made to give such efficiencies, which, in view of the prophecy of scientific men that no such thing was feasible and the contention of practical men that it was an impossibility, was certainly of interest. Dr. Unwin, in his remarks, had pointed to the need for making up leeway in the matter of science, and in this relation the speaker felt that if anything were to be accomplished on the scientific side of gas engineering and motive power it would be needful to begin at the beginning. In conclusion, he would repeat that he had no further information which was outside the paper itself.

Captain H. Riall Sankey opened the discussion. He felt that the data of the paper could be accepted with confidence. The interest of the paper had been greatly increased by the important information given by Professor Burstall. The speaker agreed with the professor in his want of faith in the Diesel engine, and believed that the future was with the miscalled "semi-Diesel." Referring to the high thermal efficiencies of the small engine, to which Professor Burstall had directed attention, it would appear from Table II that the brake efficiency of the engine was only 66.55 per cent. at three-quarter load, the thermal efficiency being 43.8 per cent.; the brake thermal efficiency was therefore only 29 per cent. The speaker considered it quite possible that the so-called semi-Diesel engine would not have quite so good an indicator thermal efficiency as the Diesel engine tested, but the brake thermal efficiency—with which the user had to deal—would probably be better than 29 per cent. The paper was, in a great measure, an application of Professor Burstall's energy diagram, published in the "Proceedings" in 1911, but not discussed. That diagram was a most interesting one, and Captain Sankey pointed out that there were six pairs of gas characteristics, or six things which were put into pairs, which could be plotted vertically and horizontally, and with equal divisions. These were pressure and volume, the total heat and the internal energy, the temperature and entropy. Pressure-volume were already a well-known pair of ordinates, as were also temperature-entropy and total heat-entropy—the Mollier chart. A fourth pair could, however, also be used, viz., pressure and internal energy. Fig. 7 in the paper showed the abscissæ to be equal divisions of pressure and the ordinates to be equal divisions of internal energy. Whichever pair of the six things mentioned was adopted as ordinates, they could be similarly portrayed by means of curves. Sometimes these curves became straight lines. It might be interesting to state that out of the six pairs it was possible to make 15 different kinds of diagrams, of which, so far, only four were actually in use; what might be in the other 11 he did not know. He had replotted one of the indicator diagrams on the temperature-entropy or theta-phi chart, so that it might be possible to compare that method of plotting with that adopted by Professor Burstall.

Beginning at the point A, on the extreme right of Professor Burstall's diagram, it would be seen that there was a small vertical rise, the end of which was at *a* on the theta-phi diagram. Fig. 1 annexed, Then Professor Burstall's diagram sloped from A_1 A to a point in B, which was at the highest temperature, and *a b* was the corresponding part of the theta-phi diagram. Then in Professor Burstall's diagram came a drop in temperature, the line going to the left all the time, arriving at the point *c*. Later on the professor's diagram reached a point which the speaker had marked as *x*, and still further on to another point, also not marked on Professor Burstall's diagram. The remainder of the cycle—at any rate to the point *d*—was completed on constant volume, 14.48 on Professor Burstall's diagram. Then the remainder of the lower part of the diagram was represented by the line *d e a* on the diagram, Fig. 1, put forward by Captain Sankey. All the various heat exchanges given in the paper could also be followed on the theta-phi diagram, Fig. 1. It was for instance, pointed out in the paper that the expansion was adiabatic from the point *c* to the point *x*, but there was a loss of heat, which was made up on return. The speaker's diagram illustrated this point. It had also been stated that towards the end of compression the temperature was almost constant. This was also shown by the part *e a* of the diagram being nearly horizontal. There was, however, one

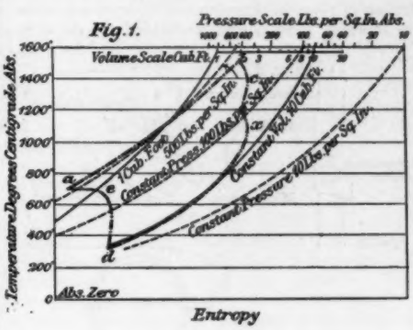


Fig. 1.
Pressure Scale Lbs. per Sq. In. Abs.
Volume Scale Cub. Ft.
Temperature Degrees Centigrade Abs.
Constant Pressure 500 Lbs. per Sq. In.
Constant Pressure 100 Lbs. per Sq. In.
Constant Vol. 14.48 Cub. Ft.
Abs. Zero
Entropy

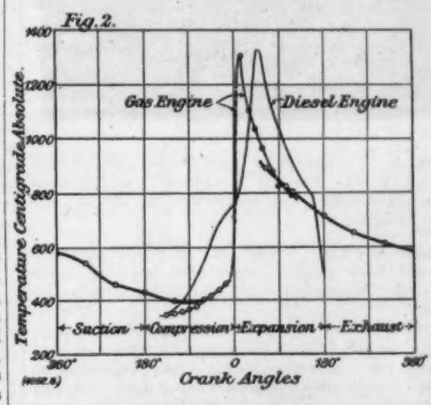
difference. The temperature at the top of the diagram, Fig. 8, was 1,450 deg. as against 1,335 deg. obtained by Professor Burstall. The speaker had not had time to check the difference. Doing the best he could, he could get no other result; the difference might be due to wrong plotting on his part. He proposed, however, to replot it more accurately, and any mistake he had made would be corrected in the "Proceedings." On the other hand, the difference might be due to the fact that pure nitrogen was taken as the gas in the one case, while, in the other, the diagram was drawn for the products of combustion in the Diesel engine. That, of course, affected the variation of specific heat to a certain extent, and might account for the departure in temperature. In that connection he would ask Professor Burstall at what temperature the charge-weight in the case of the full load trial was taken. (In the paper the figure was 0.01376 lb.) He would further inquire why the initial or suction temperature was taken as 322 deg. C. That, of course, was absolute, so the temperature of the charge at the moment the piston started on its compression journey would be 49 deg. C. That the speaker regarded as rather a low temperature, but perhaps Professor Burstall could give information on the point, as also whether the temperature was actually measured by the thermometer at any part of the stroke.

Mr. E. J. Davis remarked that the mechanical efficiency, as given, seemed rather low, but on looking at the indicator card he had found what might be a possible explanation. There was a swirling on the expansion card which he had not previously noticed in the case of Diesel engine cards. Of course if the mean pressure, as given by the test, were higher than the actual mean pressure it would lower the mechanical efficiency. As the speaker had pointed out when discussing Professor Hopkinson's paper on an optical indicator, such an indicator had one great disadvantage in the fact that what might be called the card was not fixed to the engine, as in the case of an ordinary indicator, so that if there were any vibration at all it was accentuated on the card itself, and there was thus liability to inaccuracy.

Professor E. G. Coker observed that the paper by the late Lieutenant Wilkins gave evidence of the great care used to obtain accuracy in the measurements for determining the heat balance and the distribution of the flow of heat. Among the points very fully brought out was the detailed analysis of the temperature changes which were going on in the charge. As had already been pointed out, after-burning apparently occurred throughout the stroke in this engine, and this phenomenon differentiated the case from that of a gas engine. Fig. 9 in the paper indicated the temperatures in the cylinder of an 8 brake horse-power Diesel engine on a stroke basis, as well as on a crank angle basis, and, adhering to the notation of the paper, he would point out that the author had given the temperatures at the top of the peak for half-load as about 1,080 deg. C., at three-quarter load as about 1,200 deg. C., and at full load as about 1,330 deg. C. This seemed rather higher than with a gas engine of about the same power, but when it was remembered that these readings were from the absolute zero, the agreement with gas engine measurements was very satisfactory. In this relation the speaker thought it might be worth while to give the determinations made with another internal combustion engine, especially as they appeared to confirm the author's results, although somewhat indirectly. In a National gas engine, tried by Mr. Scoble and himself at Finsbury,* it was found that, with nearly full load and an average charge of air and gas of about 7 to 1, the temperatures were from 1,275 deg. C. to 1,325 deg. C. in ordinary running with firing at every cycle, while with a very strong charge, corresponding to the maximum which the engine would stand, for a few minutes only, the figure was about 1,505 deg. C.; this latter figure was rather more than was obtained with the Diesel engine. There were several points of interest in these diagrams, and he would illustrate his remarks on these by sketches on the blackboard. In the experiments to which he was referring the temperature was obtained directly, except at the very top of the peak, and the temperature measurements are indicated on Fig. 2, subjoined, by circles connected by strongly marked curves, while some calculations of temperature, obtained indirectly, are shown in a similar manner, and connected by fine lines.

At the end of the compression the temperature rose so rapidly that it could not be measured, and there is a gap which includes the peak, for which direct measurement proved to be unreliable, but for the remaining part of the cycle there are a good many points of observation. The part not measured directly was filled in by observations from indicator diagrams, and was extrapolated from the relation PV = RT, where P and V were known and T was a value taken as high as possible on the expansion line of the diagram.

The temperature diagrams in the present paper show some interesting variations, and for convenience of comparison the full load temperature curve was plotted on Fig. 2, from which it would be observed that at about the time when the fuel valve opened there was strong evidence of a shoulder in the curve, followed by an upwardly sloping line in marked contrast to the sudden change of temperature in the gas engine indicated by the dotted line



and almost coincident with the zero ordinate. It was therefore very probable that the sloping line was due to after-burning, and when the maximum temperature was reached the fall in temperature appeared to be similar to the gas engine, but a shoulder was shown well down on the expansion line which was not very apparent in the experiments at Finsbury, although

* "Cyclical Changes of Temperature in a Gas-Engine Cylinder," by Professor E. G. Coker and Mr. W. A. Scoble. Proc. Inst. C.E., vol. cxcvi, Part ii 1913-14.

on looking for it recently the speaker had found traces of such a discontinuity, which had been previously missed. When these curves were discussed it was pointed out that the temperature measurements were obtained by intermittent readings taken over a small arc of the engine revolution, and that they were mean values for the arc, so that it is necessary to take the latter as small as possible, and that probably a better way to obtain them would be to use some means for getting a continuous record of temperature by the aid of a thread galvanometer. This form of experiment had been discussed previously, and with the help of the Cambridge Scientific Instrument Company further experiments were carried out and some temperature diagrams obtained for the gas engine referred to, and also for a small steam engine. These photographic records were shown and described at the 1914 meeting of the British Association in Melbourne.* Figs. 3 and 4 showed two of these curves, the former being that obtained when the gas engine was running under the control of the governor, and the latter when the governor was not operating and firing was arranged to take place at every stroke. In these records there were marked pauses in the slope of the rising and falling curves, the reasons for which were at present somewhat obscure, but they were mentioned here because the present paper showed curves with similar characteristics. Mr. Eden was now investigating the action of the galvanometer

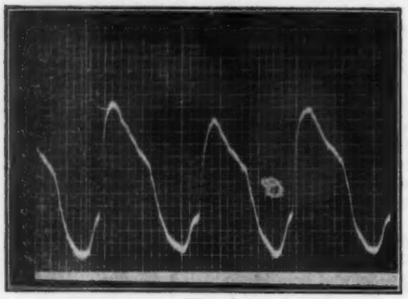


Fig. 3.

Fig. 3. Temperature Changes in the Charge of a Gas-Engine Cylinder when Explosions occur at Every Stroke.

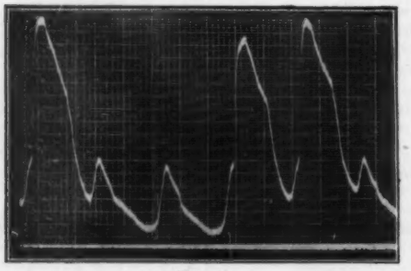


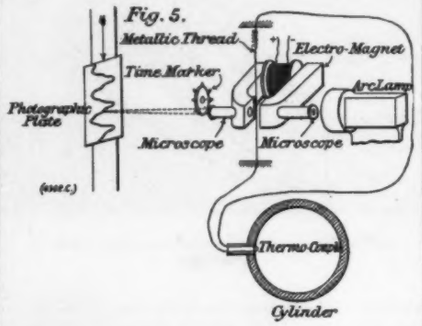
Fig. 4.

Fig. 4. Temperature Changes in the Charge of a Gas-Engine Cylinder for Several Cycles when the Governor is acting (not Calibrated).

under very rapid changes of E.M.F. like that produced in a thermo-couple when exposed to an explosion temperature, and also the lag of the couple itself.

Some of the curves obtained appeared to show that the shoulder on the expansion curve occurred somewhat before the opening of the exhaust valve, but only further experiment could decide whether this was so, or if it was an effect due to the instrumental means employed. The speaker desired to ask Professor Burstall if he had found similar effects in his Diesel engine, or in any other engine of a similar character.

It might perhaps be of interest to explain how the photographs of temperature change were obtained. If a very fine metallic wire, through which a current was passing, was stretched between the poles of a horse-shoe magnet in a direction at right angles to the field, it would be deflected perpendicularly to the lines of magnetic force, and if the ends were fixed the motion at an intermediate point of the thread might be used to measure the current in the wire. The accompanying diagram, Fig. 5, showed the arrangement of the Einthoven galvanometer employed, in which an electro-magnet, with a very strong field between the poles, was provided with a microscope fitting into the pole pieces, to throw a magnified image of the moving thread on a photographic plate, which latter was allowed to fall at constant velocity. A time marker operated by independent means rotated in the field of view and produced vertical parallel lines on the photographic plate, at known intervals of time, in this case 0.04 of a second, while a cylindrical lens, suitably divided on its face,



marked equal intervals in a direction at right angles to the time markings. If the ends of the wire were connected to a thermo-couple exposed to varying temperature, the movement of the thread corresponded to the temperature of the couple, and this movement could be calibrated to afford a measure of the temperature. To ensure that the movement of the wire should be in phase with the change of temperature or other phenomenon it was desired to measure, the tension of the wire was adjusted to keep the deflection very small, and of the order of 0.01 of an inch, while the magnification was large—600 in the instrument used here—to give a large diagram. Experiment showed that under these conditions the instrument was nearly dead-beat in its indications, and with a scale of 1 millivolt per centimetre the latest measurements of Mr. Eden indicated only a small amount of lag at the extreme points when a current was suddenly switched on to the circuit containing the galvanometer thread.

Professor Burstall then replied, very briefly, to the remarks which had been made. In reply to Captain Sankey's question as to temperature, he would say that a temperature of 60 deg. was assumed. No temperature was measured at all, and the difference between Captain Sankey's temperatures and those shown by the speaker's diagram were unquestionably due to the fact that Captain Sankey had based his calculation on the products of combustion, whereas the speaker had used pure nitrogen. Professor Burstall's reason for using pure nitrogen was this, that while he had every confidence in Holburn and Heming's results with regard to pure nitrogen, he had not the same faith in their accuracy for water vapour. He determined, therefore, to use that about which he was certain, leaving the user of the diagram to correct it for himself. In regard to Professor Coker's figures, he thought these would be found to agree much more nearly with those of Lieutenant Wilkins if it were borne in mind that the whole of the temperatures given in the paper were absolute. If to the figure of 1,050 deg. C. 273 were added, the difference would not be serious. In relation to the temperature questions in connection with the Diesel engine, raised by Professor Coker, he would say that, some six or seven years ago, the Dutchman, Peterson, either at Leyden or Utrecht, carried out experiments embracing the whole of those questions and plotted the results. This had been done with the aid of an Einthoven string galvanometer combined with the use of a fine platinum wire and a cinematograph camera, an arrangement which the speaker had himself proposed. There was no attempt to attach the device to the engine itself; the practice now would be to cause the cinematograph film to travel at a great rate past the spot of light, straightway removing all source of error. With regard to the optical indicator he thought there was no doubt that it was a much more accurate instrument than any form of spring indicator. As had been stated, the engine was very small—8 h.p.—and therefore he considered the results were respectably good so far as mechanical efficiency was concerned.

Dr. Unwin then announced that the Thomas Hawksley Lecture would be delivered by Mr. Harry E. Jones at the Institution of Civil Engineers, on Friday, November 3, at 6 o'clock. The subject would be "The Gas Engineer of the Last Century." He believed Mr. Jones had taken much trouble to illustrate his subject. With this announcement the proceedings closed.

* "Temperature Cycles in Heat Engines," by Professor E. G. Coker and W. A. Scoble, B.A., Report 1914, p. 512.

THE BRITISH ASSOCIATION.

(Concluded from page 378.)

SECTION B.—CHEMISTRY.

Exhibition of British-made Chemicals and Apparatus.

The already-mentioned exhibition was well stocked with noteworthy products, chiefly, but not only, of the district, especially products of most recent dates, instructively displayed in most instances. The fused silica or "vitreosil" flasks, pans, coils, &c., of the Thermal Syndicate, of Wallsend, made a very fine show; next to them were exhibited glass and porcelain apparatus by various firms. The North British Rubber Company, of Edinburgh, showed a variety of vulcanite articles for the chemist and engineer; the High-Speed Steel Alloys, Limited, of Widnes, and the Newcastle Alloy Company displayed their tungsten and other alloys; Messrs. Cookson and Company exhibited lead and antimony, the latter of which they alone smelt and refine now in North-East England; Messrs. Evans, Adlard and Company, of Postlip Mills, Winchcombe, showed that pure filter paper can be made in England. The chemical works of Sir Jesse Boot, of Nottingham, had arranged for a large display of their chemicals and drugs; Messrs. T. and H. Smith, of Edinburgh and Glasgow, made their alkaloids, caffeine, brucine, morphine, and also chloroform, &c., quite tempting; and British Dyes, Limited, of Huddersfield, demonstrated by specimens and samples that many of the colours of the rainbow in their endless variety have been produced in England since the outbreak of the war.

The Characters of Coal Varieties.

"The Investigation of the Chemical and Microscopical Characters of different Varieties of Coal, with a view to their most Effective Utilisation as Fuel and to the Extraction of By-Products," was the elaborate title chosen for a joint discussion of Sections B and C, Geology, which was held on the Thursday morning of the meeting, Professor W. S. Boulton, of Birmingham, the president of Section C, being in the chair.

The discussion was opened by Professor G. A. Lebour, D.Sc., of Newcastle, who said that the geologist regarded coal as a rock, disposed in layers or seams, sandwiched between a roof and a floor of other rocks, and subject to interruptions in continuity and to changes in thickness and also in physical properties and composition. To investigate the latter the geologist needed the help of others. The geologist's business was to find the coal, either by mapping its outcrops or, if there were none, by weighing circumstantial stratigraphical evidence of all sorts, enabling him to point out the possible extension of coalfields and the existence of hidden fields. As regards the composition of the coal in the seam, as a whole or in its different parts, he had to turn to the chemist, who, Professor Lebour hoped, might be induced to provide the information asked for in a more uniform manner than was usually done. For geological purposes both an ultimate analysis and an ordinary commercial analysis (percentages of fixed carbon, volatile matter, ash) were necessary; one analysis alone (especially the former) was useless. If the chemist could be informed of the nature of roof,

floor, &c., in which his sample occurred, much good might result. One seam of coal in the Newcastle district yielded in one position the best steam coal, in another the best household fuel, in a third the best coking coal of the district. The geologist looked for a better classification of chemical coal analysis and the co-operation of chemistry and geology in investigating the coal problem. After 50 years of coal work he himself felt that he knew less about what coal was than he had thought he knew at first.

Professor A. W. Bone said he shared that feeling, and the desire for co-operation of the chemist with the geologist and palæobotanist. Chemists had little to say of a definite character as to the true nature of coal and had reason to feel diffident. They analysed and applied tests and solvents, but little had been done so far as to the correlation of the results.

Professor P. F. Kendall (Leeds), speaking as a working geologist, said that the chemist mostly did not know where his sample actually came from. In many coal seams intricate layers of bright, clean and of dull, dirty constituents could be distinguished, differing possibly as to botanical origin or as to conditions of accumulation; the bright coal might have been bark, the dull leaves. Professor Green had found 1 and 2 per cent. of ashes in bright, and 6 and 7 per cent. in dull coal; the densities also differed. Ordinary chemical analyses gave too little information; the ash might be intrinsic to the plant, it might be dust, it might be otherwise introduced mineral impurity (pyrites, &c.); they were now applying X-rays at Leeds for this study. The proportions in the ash of silica, alumina, iron, &c., fluctuated strongly; there was generally much calcium and very little potassium, and the peculiarity of this ratio was not explained. Calkspar occurred in streaks, from which anthracite was free; anthracite was deficient in the dull, ashy coal moreover, but Irish anthracite was high in ash and resembled cannel coal. American geologists generally considered that anthracite and coal differed in original constitution; Professor Kendall was doubtful on that point.

Dr. G. T. Dunn admitted that chemists worked too much on independent lines. But when Professor Lebour asked for classification, he demanded more than chemists could give. Their classifications were artificial and empirical, and had their usefulness, as the botanical system of Linnæus had had a real value before a natural classification became possible. Chemical analyses were mostly made for some specified industrial purpose, to determine ammonia, volatile products, coke, &c., not for scientific purposes; no information was available as to geological horizon in most cases. The geologists should put definite problems. Dr. Dunn referred to some peculiar cases of ash distribution in samples of coal, as to the geology of which he had no information. One coal contained 20 per cent. of pure china clay, so finely distributed that every microscopic particle of coal contained its particle of ash; the ash of another coal was practically a rich iron oxide. The problem of coal research should be taken up by the State, as had been done in the United States and also in Canada.

Professor Bone here interposed the remark that he was not betraying any State secret when he stated that the Government would take up this problem in the very near future with adequate grants; this was partly owing to the movement on Fuel Economy started at last year's meeting of the Association.

Professor P. Phillips Bedson, of Newcastle, reminded members that the Association had appointed a Committee on "The Proximate Constitution of Coal" in 1893, and that the Committee, of which he was secretary, had presented reports in 1894 and 1896 dealing with the solvent action of benzene, turpentine, and other solvents, with oxidation and chlorination, &c.; they had then rediscovered things known in 1838, and their own reports had been overlooked; the best way to hide a thing was to publish it.

Subsequently, in the afternoon meeting of the Chemical Section, Professor Bedson showed "An Apparatus for Grinding Coal in Vacuo," a very simple device, convenient, he explained, for studying the gases contained in coal and liberated while the coal was being ground. It was a cylindrical vessel bulging out in the middle portion, of stout glass, about 9 in. long; the coal and iron balls for the grinding were introduced through the one end, which was then closed by a sealed-in stopper through which a glass tube passed to an air pump; the other end was closed. The cylinder rested horizontally in bearings and was rotated by the aid of a pulley, being at intervals connected with the pump to remove the liberated gas.

The discussion in the Joint Section, from which we had turned to mention this useful device, was, after Professor Bedson, continued by Mr. D. Trevor Jones, M.Sc., who gave an account of some further experiments he had been conducting, together with Dr. R. Vernon Wheeler, at the Home Office Experimental Station at Eskmeals. We have on other occasions commented on this work. By treating coal with pyridine, he explained, they obtained an extract and a cellulosic residue A; the extract, further treated with chloroform, gave insoluble residue (again cellulosic) B, and an extract of resinic compounds C. A and B were infusible, C softened at about 100 deg. C; on exposure to air only C was oxidised like the resins and acted then on a sensitised plate. A and B, distilled in a vacuum, yielded the same gases and liquids in kind and quantity, whilst C gave different products. A and B lost little liquid by weight, and the distillate consisted of phenols; C lost half of its weight at 450 deg. as a liquid which resembled the tar of low-temperature carbonation and was free from phenols. That A and B yielded phenols was characteristic of celluloses and degraded cellulose derivatives, of which only a few were probably present in coal, whilst the resinic compounds in coal were of a much more diversified character and polymerised by high pressure; hydrocarbons were among these latter, though paraffin hydrocarbons were only present in small quantity. The presence of free carbon in coal seemed unlikely. Low temperature coal distillation might be said to yield a kind of petroleum; but Mr. Jones did not assume with Pictet, Ramseyer and Bouvier that the similarity indicated more than a partial identity of the parent vegetable substances. The presence in the coal-petroleum of phenols, their absence in natural oils, and the stability of the phenols rather suggested a different, non-vegetable origin for natural oils. The conclusion of Mr. Jones was that coal had been formed from decayed vegetable matter by the action of pressure and temperature, the latter probably remaining below 300 deg. C.

Dr. Marie C. Stopes, another collaborator of Dr. Wheeler's, discussed the "Structure of Coal" from the standpoint of the palæobotanist. Palæobotany had established that some, if not all ordinary bituminous coal, was formed from a mixture of various kinds of land plants. No living plant was simply divisible into cellulosic and resinic constituents. Some of the plant constituents might be slight variations of the complex cellulose molecule, but the different portions of even the simplest land plants were composed of a great variety of chemical compounds. If different by-products from coal were traceable to specific parts of plants, and if these parts were recognisable in the coal, a great step would be made in our knowledge of coals and their potentialities. Dr. Wheeler and the speaker had tried to ascertain whether the various modifications of cellulose differed materially in the compounds they yielded, and if so, which part of the plant substance corresponded to any particular coal derivative. They had been successful to a certain extent. They had found that the yellow spores, conspicuous in sections though hardly recognisable in lump coal, were still in a condition to react distinctively to treatment by pyridine; large numbers of unaltered spores were observed in the insoluble pyridine residue, and that showed that the particular modification of cellulose forming the spore walls was one of the cellulosic derivatives insoluble in pyridine. Other coal constituents they had isolated were cuticles which consisted essentially of cutin, and they were now submitting these cuticles to distillation.

Dr. G. Hickling, of Manchester, uttered a note of warning. The palæobotanical studies were, no doubt, most fruitful, but decomposition of the original coal constituents might be more important than the constituents themselves, and the substance of the spores isolated would hardly be unaltered. Any seam of coal was a complex mixture of different types of coal. The differences between the bright and dull kinds of coal were striking to the eye; the microscope revealed further, much greater, differences. Another speaker said that he had etched the coal like metallurgical specimens and had gained some definite information by these means. Professor Boyd Dawkins also advised caution in drawing conclusions as to the original constitution of coal; elements not in the original plants might have taken up the position of the original elements. There was of course, general agreement as to the need of systematic co-operation of scientists of all branches in the investigation of the coal problem. But it is hardly creditable to science in general that such a co-operation should have to be urged in our days, when big volumes have been stuffed with accounts of research and analyses, and committee reports have been compiled and shelved. Uncontrolled research has done much to discredit research.

Stepped Ignition of Gases.

Professor W. M. Thornton, of Newcastle, gave a demonstration of his experiments on "Stepped Ignition of Gases." He pointed out that when the frequency of collisions between the particles (molecules or atoms) of the combining gas (hydrogen, methane, other hydrocarbons, &c.) and oxygen was varied by changing the proportions or pressures of the gas in the explosion vessel, the inflammability (measured by the least current, potential or capacity required to produce ignition) was found in many cases to vary suddenly, in a series of steps, either up or down. The effect seemed to be caused by a selective absorption of energy. When the collision frequency between the combining gases passed through successive multiples (or sub-multiples) of that frequency which gave perfect combustion in the mixture at atmospheric pressure, there was a sudden change in the amount or form of the energy which had to be imparted to the gas by the spark to start inflammation. The origin of this selective action was obscure. It was not chemical, i.e., not dependent upon the formation of different stable combinations at each step, nor thermal, for the temperature of a gas depended on its translational energy, which did not undergo a sudden change.

There remained the vibrational energy, giving rise to radiation, and the rotational energy. If the effect were due to radiation from the atoms, it was difficult to see why it should in some cases cause a step upward and sometimes a step downward, and why it should in either case change suddenly. But the rotation of a freely spinning body was greatly affected by its collisions with other bodies, which would adhere to it for a time; any action calling forth excessive spin would of necessity retard the rise of translational movement and thus of temperature. Evidence for the momentary existence of excessive spin might be found in the so-called suppressed temperature of an explosion, in the fact that the amount of radiation did not exceed 25 per cent of the whole energy of combustion, and in the reversed spectrum of an explosive wave—which, seen from the front, with the wave advancing towards the spectroscope, showed every line reversed, but seen from the back showed the lines bright and normal. Vibration was therefore suppressed at the moment of combination; the pressure being halved, there was only the excessive spin left to take up the energy of combustion. The mechanical conditions affecting rotation might explain the steps. Relatively inert molecules behaved like hard elastic spheres, but molecules which combined did not so behave for the moment of contact. If the collisions (with combination and extra spin) occurred before the excess spin of a former collision was reduced by neutral collisions, the rise of translational energy could be delayed. The steps would appear to depend upon the relation between these times of reduction of spin and of collision, and might, in that case, be more difficult to observe in heavy gases (pentane, petrol vapour) than in light gases.

In demonstrating a step in a mixture of hydrogen and air kept at atmospheric pressure Dr. Thornton altered the capacity of the condenser circuit in steps of 0.01 microfarad, and he showed that, while mixtures were inflamed by the same discharge

TURBINES AT THE BULLERFORS HYDRO-ELECTRIC POWER-STATION.

CONSTRUCTED BY THE KARLSTAD ENGINEERING COMPANY, KRISTINEHAM, SWEDEN.

(*For Description, see opposite Page.*)

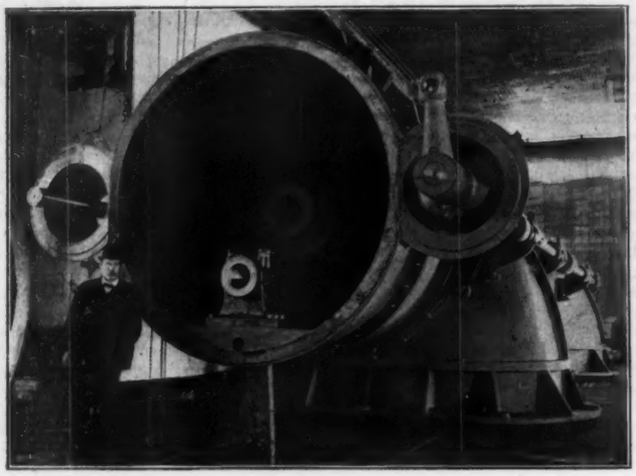


Fig. 1.

Fig. 2.

when the hydrogen percentage was raised from 20 to 27 and 28 per cent., the required capacity rose suddenly when the hydrogen percentage increased from 29 to 30 per cent.

Nickel, Iron and Carbon Monoxide.

Dr. J. E. Stead contributed several notes, which he illustrated by means of slides, on "The Oxidation of Nickel Steel," on "The Reduction of Solid Nickel and Copper Oxides by Solid Iron," and on "The Disruptive Effect of Carbon Monoxide at 400 to 500 deg. C. on Wrought Iron." Dr. Stead's observations and experiments are of considerable importance to metallurgists, and have since been discussed by the Iron and Steel Institute; we have noticed and illustrated them in our reports on the proceedings of that Institute.

A Modified Chlorination Process.

Dr. J. A. Smythe, of Armstrong College, explained in a paper on "A Modified Chlorination Process" that, while experimenting on a convenient method for making ethylene dichloride, $C_2H_4Cl_2$, he perceived that the combination of ethylene and chlorine took place easily in the presence of calcium chloride, when trichlorethane was also formed. The chlorination of benzene, yielding both substitution and addition products, was likewise facilitated by the presence of calcium chloride, which thus seemed to act as a substitute for sunlight; engineers may remember from their college days that chlorine and hydrogen do not combine in the dark, but combine explosively when exposed to light. Another point of interest in Dr. Smythe's communication was his apparatus for preparing ethylene (formerly called olefiant gas, because its compound with chlorine, the $C_2H_4Cl_2$ mentioned above, is an oily liquid); alcohol has in this preparation to be fed into heated phosphoric acid to be dried; the acid attacks glass vessels, and Dr. Smythe uses a silica vessel and an improved alcohol-feed arrangement for this preparation.

Committee Reports.

Several of the Research Committees appointed by the Chemical Section had been unable to do any work during the past year, and therefore did not present reports; this applied in particular also to some of the committees created in connection with the British Association visit to Australia in 1914 for the investigation of specifically Australian problems. Of the printed reports presented we have published that on Fuel Economy. The Committee on "Dynamic Isomerism" (secretary, Dr. T. M. Lowry) pointed out that the work of

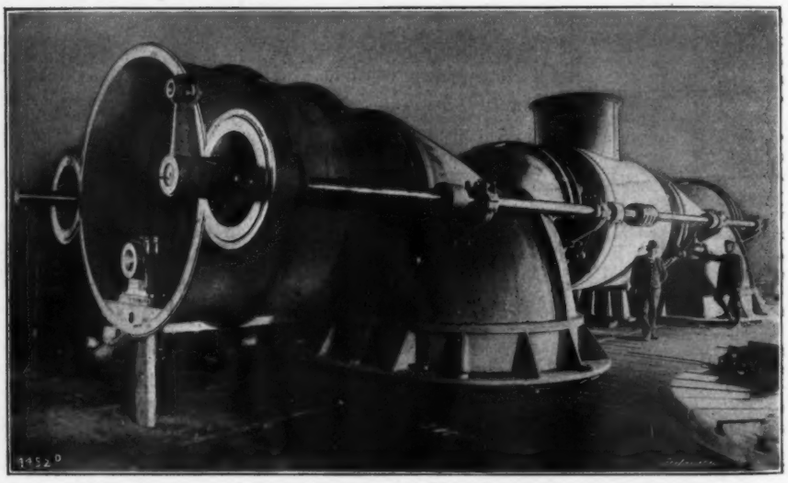


Fig. 3.

Rupe showed that most of 42 compounds of the terpene series examined (of decidedly complex structures) followed the simple rotary dispersion law, which hence could not be dependent on simple molecular structure, provided that the active substance were strictly homogeneous. "Complex" or "anomalous" rotary dispersion, especially in liquids of apparently simple character, might therefore be regarded as an *a priori* reason for suspecting some anomaly of chemical composition, *e.g.*, polymerism, association or dissociation, or dynamic isomerism.

On behalf of the Committee on Absorption Spectra and Chemical Constitution of Organic Compounds Professor E. C. C. Baly, of Liverpool, submitted a long tabular report, practically a list of literature. The committee had presented reports in 1900, 1901, 1902 and 1903. A great deal of work has been done since, and the present very useful report brings the alphabetical list of organic compounds, the absorption spectra of which have been measured, up to date; fluorescence and phosphorescence are similarly tabulated.

Concluding Remarks.

We have dealt, as far as space enables to go, with questions of general interest brought before other sections. There was much more in the proceedings of Section F, Economic Science and Statistics, that would have called for notice, if the same subject had not been discussed in other connections. Of the two evening discourses delivered only that by Professor A. W. Bone, on "Flame and Flameless Combustion" calls for mention; his demonstrations of the advance of explosion waves in long glass tubes were very remarkable.

Scientifically, the Newcastle meeting, though small, was a decided success. Only 816 members and associates entered their names. Three times only since 1850 had the attendance fallen below 1,000, at Ipswich in 1851 (710 members), at Hull in 1853 (876), and at Swansea in 1880 (899), so that Newcastle surpasses Ipswich, but no other meeting of the last 66 years; the figures for some of the early meetings are uncertain. We mentioned the attendances at the three previous Newcastle meetings—2,400, 3,335, 2,437—in our preliminary article. Those other meetings were good in other respects too, and so was this one. The small attendance is not a criterion of primary weight in war time. It was sufficiently remarkable that a third war meeting did take place, and that arrangements for next year's meeting at Bournemouth are progressing.

Not many years ago members would sometimes ask one another whether the British Association

TURBINES AT THE BULLERFORS POWER-STATION.

CONSTRUCTED BY THE KARLSTAD ENGINEERING COMPANY, KRISTINEHAM, SWEDEN.

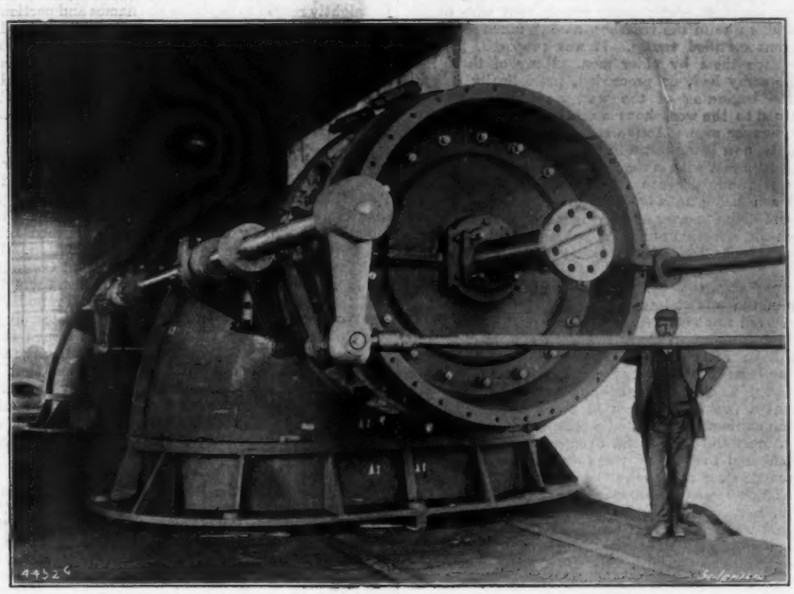


Fig. 4.

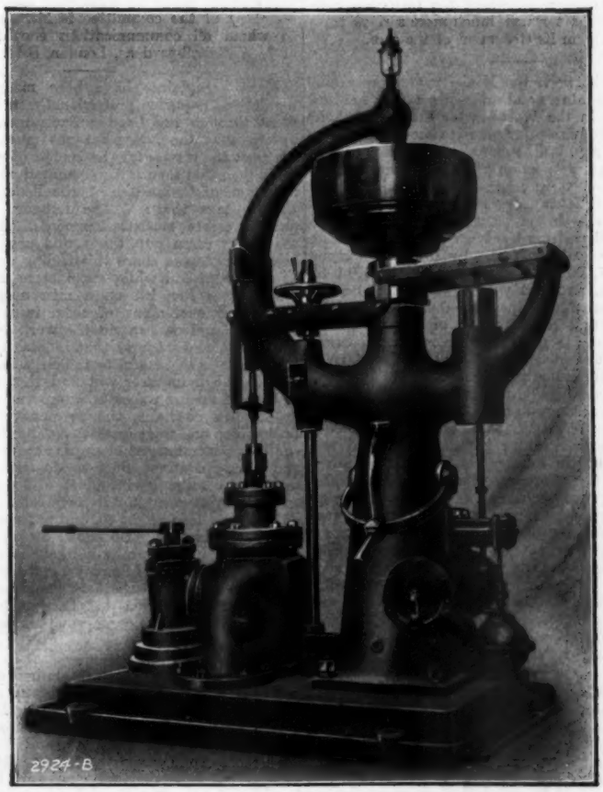


Fig. 5.

had not done its work and might abdicate in favour of the diverse scientific bodies which it had helped to arise. The war would have furnished a fitting opportunity for according a decent burial to the Association or for granting it a long vacation. But nobody has questioned the utility of the British Association of late. It is significant indeed in these days, when advisory committees and boards almost stumble over one another, that scientists of all callings, when wishing to place British geodesy on a sound footing, agreed to entrust the initiative to the British Association, which had initiated the c.g.s. measurements, seismological researches, and committees on electrical standards and on many other important matters. The small attendance has, unfortunately, reduced the grants this year available for research from the average figure of 1,000*l.* to a little over 600*l.* Section G secured the 40*l.* it had asked for the investigation of complex stresses, however; Section A was granted 170*l.* for seismology, mathematical tables, and gravity at sea; while Section B, less fortunate, obtained 55*l.*

The date of next year's meeting at Bournemouth is not yet fixed; the Association will probably assemble on Tuesday, September 17. Sir Charles A. Parsons is the president-elect.

THE BULLERFORS TURBINE PLANT.

This power plant was installed by the Stora Kopparbergs Bergslags Aktiebolags, one of the largest mining and ironworks concerns in Sweden, on the Dalelf river, on the lower course of which is situated the Alfkarleby Government Power Station recently described in our columns.

The available head of 10.2 m. is created by a hollow masonry dam, and an interesting feature is that the road giving access to the power station passes inside the dam. The head increases at low water to a maximum of 11.3 m.

The original installation, which was started seven years ago, comprised three generator turbines of 4,200 brake horse-power running at 187 r.p.m. and two exciter turbines of 450 brake horse-power. Recently three generator turbines have been added, the power being increased to 5,200 brake horse-power per unit with the same speed. The turbines are direct-coupled to three-phase 50-cycle generators and are very similar to the Alfkarleby machines. A good idea of the design and dimensions can be obtained from the photographs on the present and opposite pages, and we may add that the total shaft length of one unit is roughly 70 ft.

Each turbine consists of four wheels discharging in pairs into cast-iron suction casings. The regulating guide wheels are of the swivel vane type, the vanes being of cast steel and operated by double regulating rings moving on steel rollers. A gate shaft is placed on each side of the turbine, and the two actuate the regulating rings by means of cranks and connecting rods. These shafts are connected to the automatic governor servo-motor shaft. The turbine shaft, which is in three lengths for convenience of dismantling, runs in four bearings, three of which are of the ring-oiled white-metal lined type. The two bearings between runners No. 2 and 3 are enclosed in a water-tight casing, to which access is gained through a vertical inspection shaft. The fourth bearing at the end remote from the generator is immersed and automatically fed with grease by a compressor driven by belt from the main shaft.

The automatic governor controlling the speed of each turbine is of the well-known oil-pressure type. Fig. 5 shows the spring pendulum and the distributing valve which distribute the oil pressure in the two servo-motor cylinders. The pressure oil is supplied to all units by two motor-driven rotary pumps (one being spare). A mechanical hand regulating gear is not provided, as it would have to be altogether too heavy for such a large machine, but there is an oil-pressure hand control gear which can be used to start or stop the turbine. The new 5,200 brake horse-power turbines gave on test an efficiency of 84 per cent.

This plant has, among Swedish engineers, the reputation of being a model one, the operation of the machinery being very easy. The turbines were constructed by the Karlstad Engineering Company, at Kristineham, Sweden.

SLIDING, SURFACING AND SCREW-CUTTING LATHES.

We illustrate in the view Fig. 1 on page 400 a 12½ in. surfacing and screw-cutting lathe, with straight bed, built by Messrs. Haigh's (Oldham), Limited, machine tool makers, Oldham. The principal dimensions of the machine are the following:—

Height of centres	12½ in.
Length of bed	12 ft. 3 in.
To take between centres ...	6 ft.
Width over bed on face ...	1 ft. 8½ in.
Diameter and length of front bearing	5½ in. × 7½ in.
Diameter and length of back bearing	4½ in. × 6 in.
Diameters of cone pulleys ...	20, 16 and 12 in.
Width of belt	5 in.
Spindle speeds, 12 changes ...	9½ to 270 r.p.m.
Feeds, cuts per inch ...	32, 24, 16, 8.
Countershaft speed	120 and 160 r.p.m.
Diameter of fast and loose pulleys	16 in., 20 in.
Floor space	14 ft. 6 in. × 4 ft. 2 in.
Approximate net weight ...	4½ tons.

The lathe is of modern design, and consists of a

strong bed mounted on two cabinet legs. The fast headstock has a powerful back gear and is driven by a three-speed cone. The spindle, of large diameter and good quality steel, revolves in bronze bearings. The nose is screwed to receive a chuck or face plate, and the thrust is taken on a ball race. A quadrant plate with reversing gears for screw cutting is mounted on the end of the headstock. The bed is well proportioned, fitted with strong bars, and carries the lead screw and back shaft. The compound slide rest is provided with self-acting sliding and surfacing motions, and has hand adjustments for all directions. The screw cutting is operated from the lead screw and split nut carried on the saddle. The poppet head is with set-over motion for taper turning and with movement along the bed by rack and pinion. Two bolts are provided for clamping to the bed. All gears are machine-cut from the solid, and are guarded where necessary.

In Figs. 2 to 4 on the same page we illustrate an 8½ in. sliding, surfacing and screw-cutting motor-driven tool-room lathe by the same makers. The length of bed of this machine is 9 ft. 3 in., the width over the bed face being 14 in. It can take between centres a piece 4 ft. 8 in. long, the swing over the saddle being 12 in., the swing in the gap 2 ft. 8 in., and that in front of the face plate 11 in. The diameter and length of the front bearing are 4 in. by 5 in., the corresponding dimensions of the back bearing being 3 in. by 4½ in. There are nine changes in the spindle speeds, from 8 to 250 r.p.m. The feeds, cuts per inch, are 16, 32 and 64. The electric motor runs at a speed of 1,410 r.p.m., when it develops 5 h.p.

The motor takes three-phase alternating-current at 400 volts, 50 periods. The principal feature of this lathe is that no wheels are running in gear but those which are driving, and this applies to the feed as well as to the headstock. The fast headstock is of the all-geared type, and the nine changes of speed are through sliding gears made of steel. The steel spindle revolves in parallel bronze bearings. The nose is screwed to receive a clutch or face-plate and the thrust is taken on a ball-race. A quadrant plate with reversing screw for screw-cutting is mounted on the end of the headstock. The gap bed is with strong bars and loose gap-piece; it is mounted on two box legs. The compound slide rest is provided with self-acting sliding and surfacing motions and hand adjustment in all directions. The screw-cutting is operated from the lead screw and split nut carried on the saddle. The tailstock has set-over motion for taper turning. All gears are machine-cut and guarded where necessary.

INDUSTRIAL NOTES.

A VERY notable statement was made last week by M. Thomas, the French Minister for Munitions. From this it appears that the French output of munitions still exceeds our own, although prior to the war metallurgical industries were carried on here on a much larger scale than in France. Two main causes are probably responsible for our present relative inferiority. In the first place, Navy requirements have absorbed a very large proportion of the workshops accommodation and of the labour available at the outbreak of hostilities; and in the second place, many papers and some important politicians, when the victory of the Marne rendered our ultimate success certain, assumed that the end would be reached in the course of a few weeks or months merely. The idea of dilution met, accordingly, with much opposition, which in certain areas ceased only as the real facts of the situation were slowly realised. France appreciated the true state of affairs at the outset and has apparently carried out the process of dilution to a far greater extent than we have yet done. It is nevertheless gratifying to note that M. Thomas expects our output soon to exceed that of France, which is to-day producing three times as many 155 mm. shells as in June, 1915, and hopes soon to multiply this by five.

An important step in the further process of dilution was taken last week when the Mersey boiler makers and plumbers accepted the Government scheme for organising the work and diluting labour in the Mersey shipyards. The negotiations were somewhat lengthy, but, ultimately, agreements were come to, both with the Liverpool District Committee of the Boilermakers' and Iron and Steel Shipbuilders' Society, and with the District Committee of the Operative Plumbers' Association of Great Britain and Ireland. These agreements have since been ratified by a vote of the members of the unions concerned. The agreements proceed on similar lines to the agreement already made with the Mersey Shipwright Holecutters and Drillers, and provide for the utilisation to the best advantage of the existing skilled men, the use so far as practicable of mechanical appliances, the suspension for the period of the war of all restrictions on output, the similar suspension of internal lines of demarcation in the trades concerned, for making shipyard work so far as possible interchangeable, and, when necessary, for the admission into the trades, for the period of the war only, of semi-skilled and unskilled men and women.

Speaking at Liverpool last week, Lieut.-General Sir Pitcairn Campbell stated much combing out of *éspués* was necessary; many young men who ought, he said, to be in the trenches, having taken shelter in different certified trades. It was proposed, he said, to replace them by older men. Many of those now in the army had, he proceeded, patriotically enlisted at the beginning of the war, and should now be returned to the workshops and their places taken by the younger men. Active steps in this direction are, we note, now being taken in the Midlands. One of the difficulties met with is the fear of the workmen of what they term industrial conscription, and of unsatisfactory workmen being unbadged by the employers. In one large Midland factory employing several thousands of hands the selection of the 250 young men required for the army was decided by a ballot of the operatives.

Apparently the recent "ca' canny" trouble at Paddington was at least partly due to some such fear as referred to above. At least this would appear to be the case from an article in last week's *Railway Review*. It will be remembered that some of the employees having been convicted for being in possession of stolen property, were dismissed by the railway company, and as a protest the men at the Paddington goods station deliberately adopted a policy of spinning out to the utmost the time taken over each job. It will be remembered that a few years ago the railwaymen at Newcastle struck because an engine-driver convicted of drunkenness was dismissed by the company. This action met with general reprobation, but the claim appears to be made that the present case differs from that at Newcastle in that the men on dismissal became liable to military service. Mr. J. H. Thomas, however, managed, it is stated, to get certified employment for the men concerned, pending their appeal to Quarter Sessions, and after some demur the men at the goods yards agreed to the re-establishment of the normal working conditions. The *Railway Review* does not reproduce the evidence in which the men were convicted, and the matter was much more serious than can be gathered from its statement of the case.

A conference between the Ministry and the representatives of the miners and mine-owners was held on Wednesday last in the Westminster Central Hall, in order to try and devise some plan of checking "absenteeism" at the pits. Of course valid excuses can be found for a certain proportion of the lost time, but the percentage is now 10 per cent., taking the kingdom as a whole. Investigation shows that this figure is about twice as high as it should be, and the result of this holiday-taking disposition has been to cause a serious shortage in our coal supplies. In 1913 our output of coal was 287,000,000 tons. This fell in 1914 to 265,000,000 tons, and last year to 253,000,000 tons. Some improvement has since been effected, as the output for the first nine months of this year was 2,500,000 tons more than for the corresponding portion of last year. Yet the deficit is still said to be 15,000,000 tons below our minimum requirements. Coal owners, for their part, have abandoned exploratory and development work, thus compromising the future of their properties, but increasing the output for the present. There are, however, said to be cases in which the provision made by the management for getting away the coal as hewn is inadequate. No mention was made at the conference as to whether a larger adoption of coal-winning machines might not improve matters, and possibly the objection to such machines is less strong amongst the hewers than it was a few years ago. The most effective way of dealing with the present difficulty will probably be to de-badge the unsatisfactory workmen under direction of a Pit Committee on which the men will be fully represented, thus avoiding the risk of charges of victimisation which would otherwise certainly be made.

This plan has already been adopted in certain areas. Last week the Joint Secretaries of the coalowners and the miners of Lancashire and Cheshire (Sir Thomas Ratcliffe Ellis and Mr. Thomas Ashton) have issued the following circular to the collieries and mining lodges of the two counties with reference to men who are persistent absentees:—

"The question of absenteeism was considered by the Joint Committee at their meeting on October 2, and it was with great regret the committee learned that the attendance of some men at the collieries was by no means all that it ought to be. The committee was unanimously of opinion that the cases of persistent absentees from this time forward would have to be more efficiently dealt with, and we were instructed to invite your committee to be good enough to report to us the names of those men who are of military age who, in your judgment, are persistent absentees from work. The committee further is of opinion that the names so reported to us should be forwarded to the proper authority with a view to having their certificates of exemption from military service withdrawn.

"Will you be good enough, therefore, to make a fortnightly return to us giving the names and particulars of the time lost by those the committee regard as persistent absentees? The Joint Committee will also be glad to have the opinion of your committee as to whether the cases contained in your report should be dealt with as we have mentioned above, viz., that steps should be taken to obtain the cancellation of their exemption certificates."

Replying to a letter of protest against the alleged meagreness of the war bonus recently conceded to Post Office employees, the Postmaster-General "regrets that the Government should have been charged with repudiating the Sir James Woodhouse award before any inquiry was made as to the actual intention. Had such inquiry been made, the National Joint Committee would have been informed, as I am to inform them now, that the Government have no intention of repudiating the Woodhouse award, and that any rights accruing to the staff of the Post Office under that award stand unimpaired. I am to observe that your argument appears to be based upon the assumption that the wages of Post Office servants are settled by bargain or agreement with the Postmaster-General, and therefore Post Office servants are entitled to insist upon discussion with him. Wages are not, and never have been, so settled."

The President of the Board of Trade has appointed Sir Gerard Albert Muntz, Bart. (Chairman), Mr. Cecil Lindsay Budd, Mr. Clive Cookson, Mr. Charles William Fielding, Lieut.-Colonel A. J. Foster, Mr. Andrew Wilson Tait, and Mr. Alfred Harold Wiggin to be a committee to consider the position after the war, especially in relation to international competition, of the lead, copper, tin and such other of the non-ferrous metal trades as may be referred to the committee, and to report what measures, if any, are necessary or desirable in order to safeguard that position. The secretary of the committee is Mr. James F. Ronca, to whom all communications should be addressed at 7, Whitehall-gardens, London, S.W.

Many complaints have been made anent recent regulations requiring professional men to seek employment through the Labour Exchanges, and it would appear that the latter are not much more popular amongst the classes for the benefit of which they were initially established. A memorandum issued by the Management Committee of the Federation of Trade Unions says that: "The Labour Exchanges are out to create statistical records. It is inevitable that they often put the round peg in the square hole. Employers share this feeling quite as strongly as workmen, and while some state that the whole scheme was founded on a misconception of industrial conditions, many of them frankly declare that the trade unions can do the work better than the exchanges, and without that inquisition and humiliation which is so hateful to the Britisher. Any candid and thorough inquirer will find that the Exchanges, instead of raising wages or improving conditions, are, in fact, in constant, though passive opposition, to trade union and wage interests. The time has come to consider a retracement of steps, a recovery of freedom, and a co-operative effort to do, through the trade union movement itself, all it needs in the way of seeking employment for its members. The genuinely unemployed man ought to, and at present does, think and act for himself. He knows his own capacity; he knows the kind of job he is likely to settle down at; he knows the kind of employer he wants to work for. It is questionable whether compulsory association with, and application to, Labour Exchanges, will strengthen his *morale* or improve his personal relationship with employers."

Certain dock labourers who desired a change in the usual methods of unloading certain goods suddenly ceased work at the West Float, Birkenhead, on October 5. Last week they were prosecuted at Liverpool under the Munitions Act, and 20 of them were fined the nominal amount of 5*s.* each. It was stated on their behalf that they were unaware that they were bound under the Munitions Act to refer all grievances to the arbitration of the Joint Committee, and were precluded from stopping work in the meantime.

A suggestion is now being discussed in America for establishing by law a general contractual relationship to govern the service of all men employed on public utilities. Anyone taking up such service should, it is suggested, be required to contract to continue in the service for a specified time, and whilst proper provision would be made for release from the contract for valid cause, cessation of work for other reasons would be

punishable at law. Membership of trade unions would be permitted, but strikes prohibited, differences as to wages and working conditions being settled by arbitration. It is unlikely that any similar scheme would be seriously considered in this country, so long, at least, as public utilities are operated by private companies, and judging from Australia, there would seem to be little indication as yet that the community there is prepared to protect itself in this way against unreasonable demands by small, but highly organised sections of labour, even when the utilities in question are owned and operated by public bodies. The only strong argument in favour of a transfer of such utilities from private companies to the public thus finds no support from actual experience. Of course, even if dissatisfied workmen are legally prevented from striking they can cause very great inconvenience to the community by the adoption of "go-easy" tactics, as exemplified some years ago on the Italian State Railways, and we have ourselves had a recent experience here of this policy in connection with dispute at the Paddington goods station.

There was a dispute at Crewe over the dismissal of a workman, a delegate of the Amalgamated Society of Engineers. His reinstatement was demanded and has been agreed to.

A Proclamation has been issued by which Part I of the Munitions of War Act, 1915, is to be applied to the dispute between employers and dock labourers "in the immediate vicinity of the Port of Glasgow." The Act provides that the Board of Trade, upon receiving a report of differences between employers and employed as to rates of wages, hours of work, or conditions of employment on munitions work, shall take steps to promote a settlement. The Royal Proclamation recites that the provisions of the Act have been applied to the dispute because the Minister of Munitions is not satisfied that other effective means exist to secure a settlement "without stoppage" of work, and because "the difference is directly or indirectly prejudicial to the manufacture, transport, and supply of munitions of war."

The application of the cotton weavers of North and North-East Lancashire for an advance of wages has been acceded to at a joint conference of employers and employed held at Manchester on Tuesday. The employers not only conceded an advance on present rates of 5 per cent., but agreed that the war bonus of 5 per cent. which was conceded in January last should rank as a general advance. The application was first made about six weeks ago, and was for a 10 per cent. increase. The decision will affect nearly 300,000 weavers, of whom 70 per cent. are women. Other districts will be bound by this decision.

The kind of work on which women workers are engaged at Woolwich is described as follows in an article by Mr. Hall Caine :—Most of the work done by the women looks simple enough, and seems perfectly natural to their sex, although it has always hitherto been done by men. One woman is turning base plates for shells on a turret lathe. Another is cutting copper bands for shells from tubes. Another is pressing the copper bands into their places. Yet another is riveting brass plugs on to high explosive shell bodies. Some are drilling the holes through the 6 in. shells. Others are rough turning the shell surfaces. And yet others are gauging and parting-off the bodies of the huge 8 in. high explosives. Many are making shell fuses, a task in which women have become amazingly proficient, and many more are at work at the inspection board, where, being trained to the use of one gauge only, they have developed an efficiency to which men have never attained. All this sounds portentous in description, but at close quarters it looks astonishingly simple. The machines themselves seem almost human in their automatic intelligence, and, if you show a proper respect for their impetuous organism they are not generally cruel.

On October 20 Sir William H. Lever gave an address at the Manchester Athenæum on "Harmonising Capital and Labour," in which he stated that labour as a human element in production and distribution has not been scientifically analysed as has capital, for the guidance of capital. Labour is no longer a "hand," but is an educated man, with his wants growing and his outlook extending. He is the hope of the optimist and the despair of the pessimist. Cannot capital and labour, he said, after having fought and died side by side in the trenches of Flanders and France, be won over to fight for success of our Empire industrially after the final war victory. Sir William's plan of reconciling labour and capital is co-partnership, and the construction of a ladder reaching from the humblest position in industrial organisation to a seat on the board of directors. This partnership must be real, and not a mere division of profits. It must give to each man the stimulus and security of the man in business for himself, and must display the spirit that recognises equality and brotherhood. Sir William Lever's great success as a manufacturer and a business man is evidence that will command respectful and studious attention to his views on this most important subject.

Acting under the Defence of the Realm Regulations, the Army Council have issued an Order that in all factories, workshops, and other premises in which the business carried on consists wholly or partly in the production or manufacture of woollen or worsted goods, priority over all other work is to be given to any work which is either directly or indirectly required for the purposes of any Government contract. Returns as to the nature and amount of the work done in any of the factories and workshops are to be furnished by the owners, occupiers, their officers and servants in such manner as may be from time to time required by or on behalf of the Director of Army Contracts. Any directions that may be given by or on behalf of the Director of Army Contracts for the purposes of this Order shall be strictly complied with by such owners or occupiers and their officers or servants.

Dr. Addison, Parliamentary Secretary to the Ministry of Munitions, announces that the following scheme has been agreed upon for the release of unskilled men under the age of 30 who are fit for general service and are now employed on munitions work :—

(1) The War Office, at the request of the Ministry of Munitions and with the approval of the Labour Adviser to the Government, have undertaken that men (*a*) exempted from military service for the time being by Local Tribunals or Recruiting Officers conditionally on their undertaking work of national importance ; or (*b*) at present serving in the Army who are not fit for general service and who are surplus to the requirements of their unit, shall have laid before them an opportunity of voluntarily enrolling as Army Reserve Munition Workers.

(2) Such men on enrolling and signing an undertaking with the Minister of Munitions and having been passed to Army Reserve "W" will be found occupations suitable to them and will act as substitutes for men released for general service.

(3) The War Office, who appreciate the importance of the continued and increased output of munitions, have agreed that concurrently with this substitution a reinforcement of labour so necessary to the manufacture of munitions shall take place so far as possible from similar sources.

(4) The local operation of the scheme will be carried out by the Employment Department of the Board of Trade through their Employment Exchanges. Employers can obtain from their local exchange full information as to the details of the scheme.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

We give below a few data on several Colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Fuller information on these can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, E.C.

Australia (Queensland).—The *Queensland Government Mining Journal* (Brisbane), of August 15, reports an announcement in the local press to the effect that works are to be erected at Bowen, Queensland, for the electrolytic treatment of zinc ores. It is understood that the company concerned has for some time past been considering the advisability of putting up such works at either Townsville or Bowen, the main question to be decided being whether it would be better to ship coal to Townsville from the Bowen coalfield, where areas reserved for a State coal mine are to be developed, or to erect the works at Bowen, nearer to the coalfield, and convey the coal to that port. Evidently the decision has turned in favour of Bowen, and an application has been made to the Lands Department for the lease of an area of land at that place suitable for the proposed works. Last session the Queensland Parliament approved of the construction of a railway some 44 miles in length, to connect Bowen with the coalfields on the Bowen river.

New Zealand.—According to the Public Works Statement for 1916 of the New Zealand Minister of Public Works, a copy of which has been received from H.M. Trade Commissioner in New Zealand (Mr. R. W. Dalton), the results attained by the Government scheme for the development of hydro-electric power from Lake Coleridge, which has been in continuous operation for a complete year, have justified the most sanguine anticipations. Three units of generating machinery were originally installed, capable of an output of 6,000 h.p. Twelve months ago the demand for current warranted the installation of a fourth unit of 2,000 h.p., and the expanding business now necessitates the addition of a fifth unit, comprising pipe-line, turbine and generator of 4,000 h.p. During the year the maximum load on the plant reached 1,770 h.p., which is less than the capacity of any one of the units installed. Under these circumstances the business could not be expected to show a profit, but on the other hand, at the end of the year the plant was earning sufficient to cover working expenses. Contracts to the extent of 8,000 h.p. have already been entered into, and when the power under these contracts is being supplied it can confidently be stated, said the Minister, that the plant will be earning sufficient to pay interest in full as well as working expenses. The power has, up to the present, been utilised mainly for public (lighting, &c.), domestic and certain industrial purposes ; further arrangements are now in hand for utilising the current for tramway traction and for the operation of machinery in the principal meatworks, flour mills, tanneries, dairy factories, and the established industries in and around Christchurch. During the year feeder lines have been extended to Belfast, and arrangements are being made for a further extension in that direction to Kaiapoi.

Russia (Finland).—According to the *Pravitelstvennei Vyestnik* (Petrograd) of August 12/25, a large electrical undertaking is being founded in Southern "Esterbothnia," in which three towns and 28 rural districts are concerned. It is intended to form a company for carrying out the project, and to set up four stations for the generation of electrical power, viz., at Sturo, Ilistaro, Kurikka and Alavu. It is proposed to absorb all the small electrical undertakings at present existing in these districts. In the region covered by the operations of the new company there are many waterfalls and extensive peat deposits which will make it possible for power to be generated at a moderate price.

France.—H.M. Consul-General at Havre (Mr. H. L. Churchill, C.M.G.) reports that, according to the local press of September 28, the iron mines and blast furnaces of Caen (Normandy) are at present being worked by the Government, and that the industry which was languishing for many years past is now most flourishing. In 1900, during the period of greatest stagnation, the production of the local mines reached only about 142,000 metric tons of iron ore, as compared with 12,000,000 metric tons produced by Lorraine, though the Normandy ore is richer than that of Lorraine. In 1909 the German Thyssen interests obtained a foothold in the industry ; thenceforward considerable German and Dutch capital was invested therein. On June 1, 1914, the number of mining concessions was 21, of which 12 were being fully worked, producing annually 750,000 metric tons of iron ore. New plant of the most modern and powerful kind is being installed, and the railway authorities are doing everything in their power to assist the development of the industry. The output of iron ore in this district has now reached over 1,000,000 metric tons annually. (Metric ton = 2,204.6 lb.)

Spain.—The issue of the *Gaceta* of October 7 publishes the text of Royal Decrees, as follows :—(1) Approving the specifications for the construction of a new lighthouse at Cape Silleiro (Province of Pontevedra) and a road of access thereto, at an estimated cost of 158,253 pesetas (about 6,700*l.* at current rate of exchange). The Department of Public Works is authorised to call for tenders in this connection. (2) Authorising the Duero Hydraulic Division to continue work on the principal channels of the Queen Victoria Eugenie Canal in the district of Aranda de Duero, and allotting a sum of 144,200 pesetas (about 6,100*l.*) for that purpose. (3) Authorising the Southern Spain Hydraulic Division to continue the Andrade drainage works and allotting a sum of 1,451,110 pesetas (about 61,300*l.*) for that purpose.

Argentina.—A Decree of the National Government, dated August 21, and published in the *Boletin Oficial*, Buenos Aires, of August 24, has declared it to be obligatory on the part of railway companies in Argentina to provide heating apparatus in their passenger coaches during the winter months. The "Direccion General de Ferrocarriles" is to arrange details with the companies. The *Boletin Oficial* of August 28 publishes a Decree approving plans and specifications relative to the improvement and extension of the water supply system of the town of Paraná. The Argentine Sanitation Department has been instructed to carry out the work by administration. The estimated cost of the undertaking is 420,315 pesos currency (about 36,700*l.*). The *Boletin* of August 28 also publishes a Decree approving an *ad-referendum* contract entered into between the president of the "Comisión Asesora de Asilos y Hospitales" and the firm of Andrés Devoto Moreno for the carrying out of sanitary and water supply works at a Children's Home at Olivera, province of Buenos Aires. The contract price is 120,256 pesos currency (about 10,500*l.*).

American Metallurgy.—The production of pig-iron in the United States in August was 3,203,713 tons, as compared with 2,779,647 tons in August, 1915, and 1,995,261 tons in August, 1914 ; in the first eight months of this year the aggregate output was 22,637,172 tons, as compared with 14,664,237 tons and 14,339,360 tons in the corresponding periods of 1915 and 1914.

Electricity at Toronto.—The gross income of the Toronto Hydro-Electric Commission last year was 1,620,188 dols. ; the cost of electric current and the expenses of working and management, including repairs and maintenance, absorbed 979,209 dols., leaving a surplus on working account for 1915 of 640,979 dols. Charges and allowances, not strictly attributable to working expenses, reserves for contingencies, and grants for patriotic purposes, amounted last year to 13,773 dols., leaving a surplus available for fixed charges of 627,206 dols. Interest, depreciation and additions to sinking funds for the year amounted to 624,068 dols., leaving a final surplus on net revenue account of 3,138 dols.

THIRD-CLASS ALL-STEEL CARRIAGES FOR THE EGYPTIAN STATE RAILWAYS.

MR. R. G. PECKITT, M.INST.C.E., CHIEF MECHANICAL ENGINEER; THE LEEDS FORGE CO., LTD., LEEDS, CONSTRUCTORS.

Fig. 13.

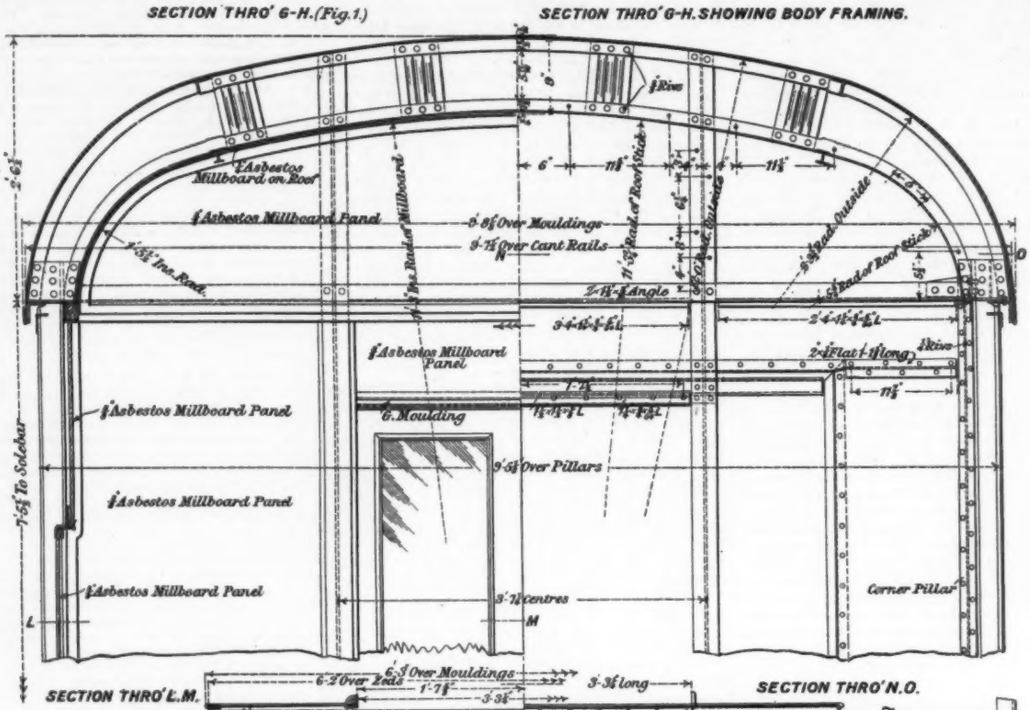


Fig. 14.

We illustrate on Plate XXXIII and on the present page and pages 409 and 412 some third-class all-steel carriages for the Egyptian State Railways which have been designed by the Leeds Forge Company, Limited, in collaboration with Mr. R. G. Peckitt, chief mechanical engineer of the Egyptian State Railways. Thirty of these were built at Leeds under the supervision of Sir Arthur L. Webb, K.C.M.G., inspecting engineer to the Egyptian State Railways.

The general particulars of the carriages are given in the table on the opposite page.

The draw-gear, buffing gear, brakework, axle boxes, wheels and axles, bogies, and general details, such as windows, louvres, seats, lavatory and other fittings, have been arranged to Egyptian State Railways standards.

These carriages are in service in Egypt, largely in connection with movements of troops, and are much appreciated. The whole of the panelling and framing is of steel throughout, lined on the inside with asbestos. They can be freely washed out with a hose pipe, without any risk of water lodging so as to cause corrosion, the floor being of Decolite cement, provided with washout plugs. They have, after careful tests in Egypt, proved themselves to be quite as cool, in hot weather, as the wooden stock. They also have the advantage that they cool down more readily than the wooden carriages after sundown, owing to the system of air circulation between the outer and inner linings.

The constructive details are clearly shown by the line drawings reproduced on Plate XXXIII, and on the present and opposite pages, while the external and internal views, prepared from photographs, given on page 412, afford an excellent idea of the carriages generally. The following special features of the design may be noted.

The underframe and body are incorporated into one structure. The body side pillars are connected at the bottom through the solebars to the boxed ends of the underframe crossbars, except at the bogie bolsters; and at the top direct to the carlines, this construction making several strong girdles completely round the body and frame. These are further stiffened by diagonal braces between the seats fixed to the pillars at the top edge, and to the crossbar flanges at the bottom edge. These braces are clearly shown on one of the photographic views, Fig. 20.

A test load of 15 tons distributed along the floor caused practically no deflection. Free air circulation is provided throughout in the body between the outer and inner linings. The asbestos lining is carried inside the body sides and the lower roof with a free air space of 8¾ in. at the roof centre.

As stated above, the design is so arranged that there is no place for lodgment of moisture in the panels and frame, and as a further means of preventing corrosion the bodies are arranged in such sections that they can be thoroughly stoved after they are prepared for erection.

The ample proportions of these carriages will be noted and much coveted by English railway engineers, the heights and widths given in Fig. 17 being all provided, it must be remembered, on 4-ft. 8½-in. gauge.

Notwithstanding these sizes we find that the existing timber coaches have tare weights per passenger of from 836 to 992 lb. Against these the steel coach has an average of 685 lb. per passenger. This advantage in weight is due somewhat to the reduced thickness of sides, permitting an extra passenger on the transverse seats. Without thus utilising this extra seating space or by giving each passenger additional room the tare weight would then show about 810 lb. per passenger.

The following summarises the advantages which have been obtained by the use of these steel coaches as compared with timber coaches: They are lighter in structure, with increased capacity. They are stronger and better able to resist wear and tear. They proved to be quieter in running. They are more economical in first cost and maintenance. There is no danger from fire. The strong construction of the ends, which have strong vertical girders with very stout corner pillar pressings, will prevent "telescoping."

North-East Coast Institution of Engineers and Shipbuilders—1916 Scholarship.—The 1916 Institution Scholarship has been awarded to Edmund Victor Telfer, an apprentice in the service of Messrs. Wm. Gray and Co., Limited, West Hartlepool. The scholarship is valued at 50*l.* per annum, and is tenable for two years. The Council, believing that the time has arrived for making the subjects of the Institution's Scholarship Examination more comprehensive than hitherto, have decided that the syllabus of future examinations shall be:—(1) English; (2) English history and geography; (3) Latin, Greek, French or German (one of these four); (4) extra mathematics; (5) and (6) either experimental science and mechanics or any two of the following: Chemistry, physics mechanics.

Board of Trade Consultative Committee.—Some interesting particulars of the work of this committee are given in a report to the Institution of Shipbuilders and Engineers in Scotland by the representatives of that institution on the committee. They state that, as in former years, numbers of points in dispute between the constituents of the committee and the Board of Trade were submitted to the committee for consideration and discussion, and were disposed of in most cases satisfactorily. The submission of circulars dealing with rules and regulations by the Board of Trade to the committee for its views before issue to the public has continued, but in rather a haphazard manner. The committee is still pressing upon the Board the advisability of issuing these circulars, giving a stated time to elapse before enforcement, say, six months. The questions of enforcing the suggestions and requirements of the International Convention for the safety of life at sea and the administration thereof have been the subject of considerable correspondence and discussion with the Board of Trade, and are still receiving close attention, as they involve matters of the greatest national importance. Another matter, arising out of the European war, is the question of the allowance of time to young engineers now on active service to count on their return to civil life before sitting for examination for Board of Trade certificates. There is also the value to be given to time served by young engineers in oil-engined ships and in the large refrigeration plants of meat boats. These matters have occupied a great deal of time and have been discussed at considerable length with the Board of Trade, and the committee trusts they are now in the process of being settled on a fairly satisfactory basis. Among the matters dealt with in detail by the committee during the year were the following: Assignment of freeboard, subdivision of merchant ships, outreach of davits, safety certificates, criterion of service, ship's lifeboats, lifeboat compasses and life-jackets.

THIRD-CLASS ALL-STEEL CARRIAGES FOR THE EGYPTIAN STATE RAILWAYS.

FIG. 15.

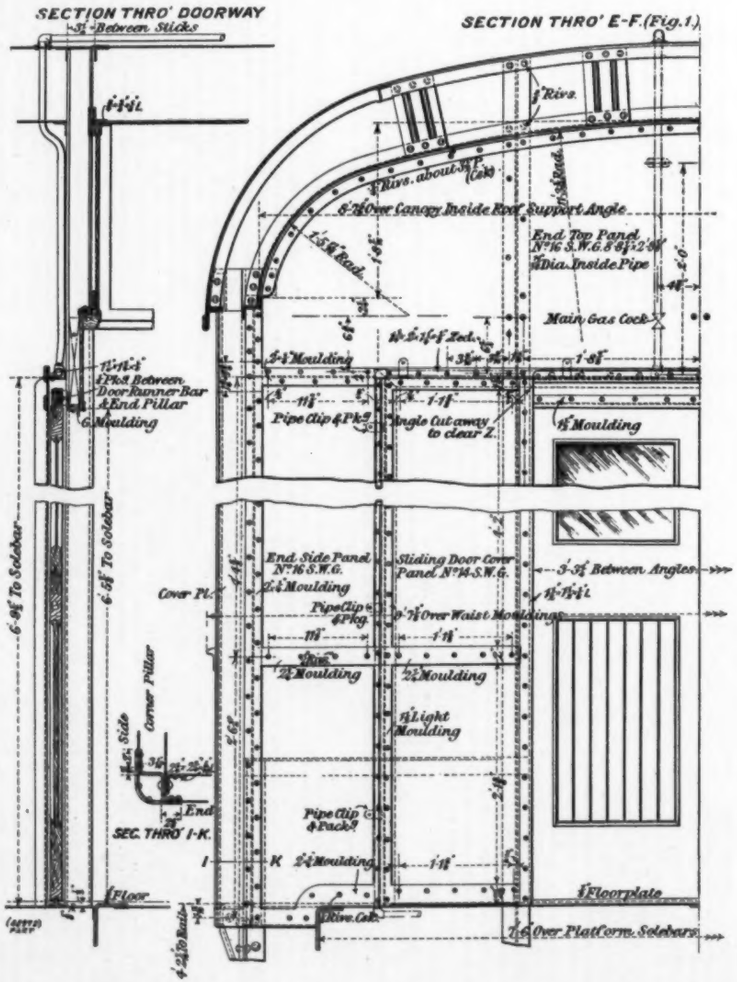
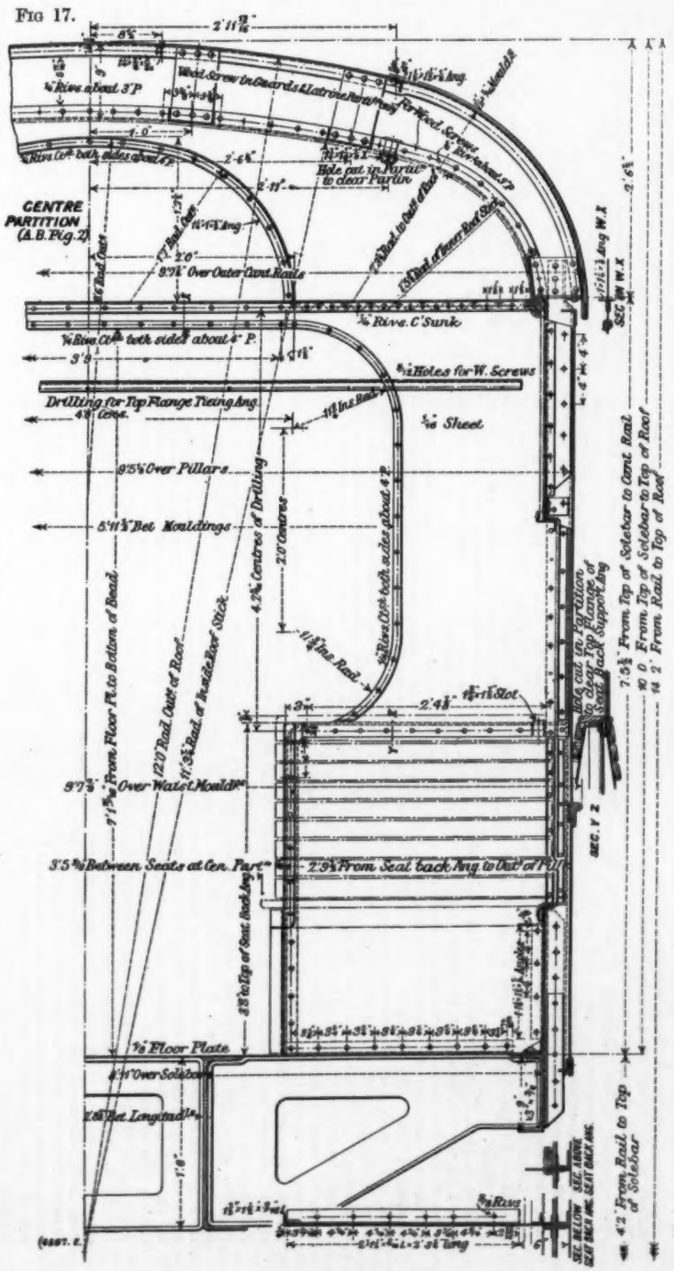


FIG. 16.

Length over buffers	69 ft. 1½ in.	Diameter of wheels	3 ft. 9 in.
Length over headstocks ...	65 „ 6 „	Centres of journals	6 „ 6 „
Width over body mouldings ...	9 „ 7⅞ „	Size of journals	9 in. by 4½ in.
Height from rail to roof ...	14 „ 2 „	Tare weight	32 tons 15 cwt.
Height inside from floor to roof at centre	9 „ 2½ „	Weight of bogies	12 „ 18½ „
Bogie centres	45 „ 0 „	Seating capacity (third class) ...	107 passengers
Bogie wheelbase	8 „ 0 „	Tare weight per passenger ...	685 lb.

FIG 17.


CENTRE PARTITION (A.B. Fig. 2)
Rivs. C'Sunk
Holes for W. Screws
Drilling for Top Flange Fixing Ang Cents.
⅜" Sheet
9'5½" Over Pillars
5'11½" Bet. Mouldings
2'0" Centres
4'3" Centres of Drilling
12'0" Rail Outs of Roof
11'3½" Rail of Saddle Roof Stick
11½" Fire Rails
9'7¾" Over Waist Mould^gs
3'5⅝" Between Seats at Cen. Part^n
2'9" From Seat back Ang to Out of P
⅜" Floor Plate
6'8" Bet. Longitds
Rivs
4'2" From Rail to Top of Solebar
7'5½" From Top of Solebar to Cant. Rail
10'0" From Top of Solebar to Top of Roof
14'2" From Rail to Top of Roof

THE LATE COLONEL THEODORE TURRETTINI.

We regret to record the death, after long illness, of an eminent hydraulic engineer whose name has often been mentioned in these columns, a distinguished citizen of the town of Geneva, Colonel Théodore Turrettini. Mr. Turrettini travelled a good deal, and was esteemed by his colleagues all over the world. A man of commanding presence and strong will, he exercised considerable influence in his native town and State, and met with marked success and also with some opposition. The Turrettini came to Geneva from Lucca in the middle of the sixteenth century, and have for generations taken a leading part in public affairs.

Born in 1845, Turrettini studied at the engineering school of the University of Lausanne, and became chief of the "Fabrique d'Instruments de Physique" at Geneva immediately after having acquired his diploma in 1867. He remained connected with this firm, which later took the name "Société Genevoise pour la Construction d'Instruments de Physique et de Mécanique," until his end, and he is succeeded in the business by his two sons. Always keeping his eyes open, he went to Berlin in 1868 to study the construction of dynamos in the works of Siemens and Halske; he worked under Hyppolite Fontaine in the electric traction experiments made at the Vienna Exhibition of 1873, and he placed himself under Edison in 1880, when the incandescent lamp was coming into use. Thus, well known, he was elected one of the experts to decide on the machinery for the harnessing of the Niagara Falls in 1891. His great experience in the hydro-electric enterprises of Geneva fully entitled him to that honour. The utilisation of the water power of the Rhône had been projected since 1867 by E. Lullin and others, and Turrettini had later submitted a project of his own. The diverse projects were hotly discussed in Geneva; when Turrettini advocated that the municipality should itself undertake the big scheme, he had the citizens on his side, and he was in 1882 appointed councillor and head of the building department; this appointment he held for 20 years. During these years the Usine de la Coulouvrenière was opened in 1886; the turbines were supplied by Messrs. Escher Wyss, the hydraulic installation was entrusted to Messrs. J. Chappius & Co., of Widau, but in *régie co-interessée* with the town. Meanwhile an agreement had been arrived at with the other Swiss Cantons or States bordering on the Lake of Geneva, and the second large hydro-electric works, the Usine de Chèvres, was opened in 1895; the municipal engineer, Butticay, superintended the operations, which were noticed in this journal. The canalisation of Geneva, the construction of bridges, extensive building operations, &c., kept Turrettini fully busy. He was also president of the Swiss National Exhibition held in Geneva in 1896. We commented at the time on this exhibition and on the Electric Congress which met in Geneva during those days. In 1902 Turrettini resigned his municipal councillorship, but was elected a member of the State Council; from 1906 to 1912 he represented his Canton in the National Council at Bern. After 1912 he could devote himself more to his own business affairs. He was also technical adviser of the "Société Franco-Suisse pour l'Industrie Electrique." He was a colonel in the Swiss artillery and a member of the Federal Artillery Commission until illness forced him to retire from public work and duties. He died in Geneva on October 7.

Books for Prisoners of War.—A list of books asked for by British prisoners of war has been issued by Mr. A. T. Davies, Board of Education, Whitehall, and can be obtained on application. Among these are works on architecture, astronomy, aviation, engineering (including civil, mechanical, electrical, marine, mining, motor, railways), mathematics, navigation, physics telegraphy and trades of many kinds. Those willing to send the books desired are asked to communicate their names to Mr. Davies. We recommend the matter to such of our readers as have technical works available for the purpose.

Empire Industrial Policy.—The Prime Minister of New Zealand, the Right Hon. W. F. Massey, has promised to speak at a luncheon of the British Empire Producers' Organisation at the Waldorf Hotel on Tuesday next, when Sir Henry Birchenough, K.C.M.G., will preside. The guests will also be addressed by Mr. F. R. Davenport, chairman of the British Electrical and Allied Manufacturers' Association, which represents various important sections of the engineering industry. Delegates of Canadian, Australian, South African, Indian, West Indian, and other Dominion industrial interests will be present, and the list of great industries represented will include railway and shipping, sugar, jute, tea, timber and rubber, general agriculture, engineering, chemicals, textile, shipbuilding, leather and other manufactures besides technical institutions and chambers of commerce. It is the aim of the British Empire Producers' Organisation to co-ordinate the efforts of sectional trade associations and further the gradual formation of a practical Imperial economic system.

NOTES FROM THE UNITED STATES.

Philadelphia, October, 1916.

The feature of the past week in the steel industry has been the placing of quite a fair volume of business for delivery during the third quarter of next year. Makers of bar steel are largely sold up to June 30. Naturally quotations have advanced. The expected advances in wire have not yet taken place. Plate manufacturers have not yet made the advance in prices so generally predicted last week; inquiries for cars now pending aggregate over 20,000, calling for 250,000 tons of plate. Prompt plate deliveries command as high as 4 cents per lb. Several large projects came before the market during the past few days, calling in the aggregate for enormous quantities of structural material. The largest pipe contract placed for months calls for 60,000 tons for a line of several hundred miles in length, running all the way from Oklahoma to the city of Chicago. By the close of the ore shipping season from the lakes some 64,000,000 tons will have been moved by water and rail from the mines for the blast furnaces. Pig-iron production again increased during September, and has again advanced and is threatened with another advance for basic and bessemer. There is not a single indication pointing to any decline in steel prices. Tin-plate prices have been increased from 3.60 dols. per box a year ago to 6.00 dols. this week. Contracts will not be accepted for more than six months future delivery. The St. Lawrence River span which fell is to be replaced as soon as possible, and 6,000 tons of material will be required for the purpose, which will probably go to the United States Steel Corporation; it is not stated how soon, under existing pressure for material, this large amount can be furnished. Special efforts will be made to accommodate the builders to avoid any unnecessary delay. The prediction is made by Charles M. Schwab that the future of steel-making in the United States will be removed from Pittsburg to the Atlantic coast, along he Eastern base of the Alleghany Mountains in Pennsylvania. This statement is made in the assumed exhaustion of the Lake Superior ore beds which reach Pittsburgh by water and by rail and the availability of Cuban and South American ore beds by water to Eastern blast furnaces.

American Coal.—The production and shipments of American bituminous coal in the first half of this year amounted to 261,000,000 tons, showing an increase over the first six months of 1915 of 35 per cent. If the rate of increase which has prevailed of late is continued during the second half of 1916, the production and shipments of bituminous coal in the United States will amount for the year to 600,000,000 tons. This would mean 25,000,000 tons more bituminous coal than the American Union has ever produced in any year of bituminous and anthracite put together. Such a record would, indeed, increase bituminous shipments to 100,000,000 tons, or approximately 20 per cent. over the last best previous record. The effect of the heavy production in the first six months of this year was not to create storage piles solely, but to satisfy an extremely heavy demand for steam coal.

American Copper Sales.—The estimated output of copper in the United States during the first half of next year is 1,000,000,000 lb. Of that quantity 75 per cent. has already been sold. America is the world's largest copper producer, and the demand now is said to be in excess of the supply, which is essentially due to the enormous purchases of copper for war purposes. An order has just been placed for nearly 450,000,000 lb. after negotiations extending over several weeks. Efforts were made to purchase at the lowest possible figure; ultimately 13¾*d.* was offered and accepted. This order for 200,000 tons for delivery during the January–June period of next year necessitates a payment of 24,966,000*l.* It is the largest single sale of copper on record, and it is doubtful whether it will ever be exceeded. As the average price of copper in the United States during 1915 was 9*d.* per lb., that of the order just negotiated shows an increase of 50 per cent. During the first half of the current year American copper producers sold in round figures 400,000,000 lb. of the metal to the Allies. The aggregate quantity of these recent sales is therefore 850,000,000 lb.; not far short of 1,000,000,000, The total amount which American producers will receive for these two sales has been estimated to reach no less than 47,900,000*l.* The large order the industry has just booked places American copper producers in an exceptionally strong position; an advance on the price now quoted is expected, and the opinion has been expressed by experts in the States that the present price, at the least, will be maintained for another 12 months. This opinion is based on the knowledge that the American domestic demand will be on a very large scale for the remainder of this year and throughout 1917. The large order mentioned above has been distributed among all American producers desirous of sharing in the business. But many held aloof, as they are under the opinion that a higher price will be obtainable in the early future due to the requirements of the metal industries. It is reported that further inquiries for 200,000,000 lb. (89,200 tons) of copper are now in the American market, also for delivery during the first half of the coming year. For domestic consumption American producers obtained orders for 150,000,000 lb. (66,000 tons) last month, for delivery between January to June next. Experts assert that even a production next year of 2,000,000,000 lb. will not suffice for the demand, even with Germany, an exceptionally large consumer, blockaded out of the market. American production cannot be increased for the present any way.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Glasgow Pig-Iron Market.—Nothing has happened during the past week to alter the condition of lifelessness which has now existed in the pig-iron warrant market for some months. A gradual depletion of the stocks in store is taking place.

Scotch Steel Trade.—Little change falls to be noted in connection with the local steel trade, and the available evidence goes to prove that, until the close of the year at any rate, working conditions will continue at the present high level, with the bulk of the output requisitioned for the use of the home and the Allied Governments. The enormous quantity of steel of all grades required for the purposes of the war absorbs practically the entire time and attention of the various makers engaged, either directly or indirectly, on Government work, to the entire exclusion of any ordinary mercantile trade. Indeed, any tonnage left over after the needs of the War Office and the Admiralty have been supplied is so infinitesimal as to be practically of little or no account, especially for export, when the stringent licensing restrictions have to be considered. Notwithstanding this, quite a number of inquiries from overseas customers are constantly coming to hand, which, however, are receiving no consideration whatever from quite a number of firms. Sectional material is being shipped in large quantity to several of the Allied countries, France, Italy and Russia being specially large buyers. No change in price has taken place during the past week—ship plates continue to be quoted about 14*l.* per ton; boiler plates, 15*l.* 5*s.* off and on; and angles, 14*l.* 7*s.* 6*d.*

Malleable Iron Trade.—Like all other war industries' the malleable iron trade keeps forging ahead, makers being better booked up with orders than, possibly, ever before. In order to conserve as much as possible the entire output for war purposes, Government is undoubtedly tightening its hold so far as the controlled establishments are concerned. Particularly is this to be observed in the steel departments, where no further business could possibly be put through. Prices keep firm, "Crown" bars being now quoted 14*l.* 12*s.* 6*d.* per ton, the better grades realising probably 5*s.* per ton in advance of this figure.

Scotch Pig-Iron Trade.—The position in the pig-iron trade continues to run on a similar level to that during the past few weeks—the strong demand for hematite being still a very noticeable feature and one likely to remain until the requirements of Government are satisfactorily fulfilled. Meantime the local steel works quickly absorb the entire available output, and little remains for the purposes of export, even were it possible to obtain licences with anything approaching ease. Home consumers are likewise in a fix, it being impossible for the makers to meet their demands, which are constant and insistent, particularly for No. 1 foundry iron, of which there is a decided scarcity. Despite this, prices remain steady and unchanged over the week.

New Shipyard and Shipping Combines.—Considerable interest has been aroused, both locally and further afield, by the latest development concerning some old-established Clyde firms. One important amalgamation which is being entered into is that between Messrs. Caird and Co., Limited, Greenock, one of the best known firms on the river, and Messrs. Harland and Wolff, of Belfast and Govan. Very little alteration will take place in the actual management of either of the concerns, the board of directors practically remaining the same. The new arrangement should undoubtedly extend the ramifications and the possibilities of the two firms, both of which have been responsible for much excellent work in the past. Not less interesting is the union which is about to take place between two of the great shipping firms—the Anchor Line, owned by Messrs. Henderson Bros., Limited, Glasgow, and the Donaldson Line, Limited, Glasgow. In forming the new company, to be known as the "Anchor-Donaldson Line," it is proposed to take over the passenger and cargo service between Glasgow and Canada formerly operated by Messrs. Donaldson. It is confidently expected that this venture will be to the material advantage of all concerned, that the business will be considerably increased, and the working expenses correspondingly curtailed.

The British Chamber of Commerce for Italy.—We are informed that a branch of this chamber has been founded at Naples (temporary address: 24, Via Guglielmo San Felice), where the local honorary secretary and committee will be pleased to deal with inquiries. Besides the headquarters at Genoa (with sample showrooms for British goods), the chamber has now four branches at the following addresses:—Milan, 12, Via Silvio Pellico; Leghorn (for Tuscany), 3, Scali d'Azeglio; Rome: 75, Via delle Terme; Naples: 24, Via Guglielmo San Felice, from all of which local information may be obtained. In this connection it may be noted that in 1913, the last year of normal trade, nearly a quarter of Italy's total imports (valued at 146 millions sterling) came from Germany and Austria-Hungary, and more than a fifth of Italian exports went to these two countries. A great decrease in trade between Italy and the Central Powers was naturally experienced on the outbreak of war, so that for the eight months from August 1, 1914, to March 31, 1915, Italian imports from Germany stand at 210,000,000 lire, and from Austria-Hungary 81,000,000 lire. Many Italian enterprises drew upon Germany, especially for raw material, semi-manufactured goods and goods necessary to manufactures, so that the rupture in commercial intercourse represents for Italy a somewhat serious dislocation.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal.—There has been a general tightening of the position all round, and supplies, though sufficient, are not coming forward with the freedom of a few weeks ago. A contributing factor is stated to be a loss of man-power at the pits, and a disinclination on the part of many who remain to work diligently. Absenteeism is altogether too prevalent. All classes of manufacturing fuels are wanted in full deliveries. Best steam hards are readily absorbed from day to day, and there is a shortage of steam nuts. Gas-making coals are going away under contract to inland works, and are also required in full tonnage for export purposes. The general export trade via the Humber continues at a steady figure to France and Italy, but that with neutrals shows a continued decline, in spite of the stronger quotations offered. South Yorkshire hards are very keenly sought by neutral consumers, but their demands are not completely met. Slacks are in a firm position at the maximum prices. Full supplies of cokes are readily purchased at high figures. The house coal position is satisfactory. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstones, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.* per ton at pit.

Iron and Steel.—The iron and steel market is practically featureless. Common irons are meeting with little demand, and the business done amounts only to a small figure. Makers have a difficulty in obtaining the official maximum prices. Finished iron works are not generally active, but the hematite trade is very brisk, owing to the constantly increasing consumption. West coast numbers are now to be had in better tonnage, and the inconveniences caused by an earlier shortage are being removed. More basic steel billets are wanted, for the American supply is not dependable, and at the present price of 14*l.* to 15*l.*, with delivery here, is not very economical. Apart from the extension and alteration of munition works, the building trade is very quiet. Few orders of any moment come to the light casting trade, for there is little demand for iron and brass work. If they were dependent upon the domestic trade iron-founders would be almost at a standstill, but they have some solatium in the shape of heavy Government orders. Makers of brass goods, who do not find the private trade provide them with sufficient employment, are able to keep full equipment running by producing certain kinds of ammunition. On a suggestion from Sheffield, scrap metal dealers intend to promote an association to safeguard their interests. The general trade of the city is brisk. All the works on tasks immediately concerned with the war report they are making excellent progress, but view with something akin to dismay the prospective combing-out of much of their able-bodied labour. File-making continues at full pressure, and there is also an abnormally heavy home and foreign demand for all classes of saws, tools, &c. A recent order for brace bits, &c., is from Australia. Cutlery manufacturers maintain a fairly large level of private business, as well as war work, but are not yet able to replace their vanished stocks, which have been eaten up by pressure of business, and this is causing some uneasiness in view of probable after-war competition. A tour of the works reveals that business from overseas is for tools, sheep shears, files, plane irons, steel cutlery, and plate.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a very firm feeling in Cleveland pig-iron, and buyers are much in evidence. Permission to buy for Scotland is given from month to month, and the removal of the embargo for November on sales to customers North of the Tweed has resulted in a rush of orders that it has been found impossible to cope with. A steady local business is being put through, handicapped though it be by certain regulations. Consumers are making inquiries with a view to covering their requirements over the first quarter of next year, but producers are not at all disposed to commit themselves so far ahead, and merchants will do forward business only subject to following any alterations in the official quotations. For home consumption No. 3 Cleveland pig still stands at 87*s.* 6*d.*, and that price also rules for No. 4 foundry and for No. 4 forge, whilst No. 1 is put at 91*s.* 6*d.* Export demand is heavy, and clearances to our Allies are maintained. With a view to easing the pressure on Cleveland iron efforts are being made to obtain supplies of Midland iron for shipment, and some Scotch iron is available for export at reasonable figures. The export price of No. 3 Cleveland runs from 98*s.* to 100*s.*, and buyers are ready enough to pay the latter figure for any parcels that can be picked up for prompt shipment. No. 4 foundry is 96*s.* 6*d.* for delivery abroad; No. 4 forge, 95*s.* 6*d.*; and No. 1 is quoted 102*s.* 6*d.* and upward.

Hematite Iron.—Very little new is ascertainable concerning East Coast hematite iron. Heavy running contracts absorb the output, and new business is very difficult to arrange. Occasional odd lots come on the market, and they are immediately secured subject to official sanction. For home use and for shipment to France mixed Nos. remain at 122*s.* 6*d.*, and for general export the quotation is in the neighbourhood of 142*s.* 6*d.*

Stocks and Shipments of Pig-Iron.—The stock of Cleveland pig-iron in the public warrant stores here is being reduced at the rate of over 2,000 tons per week. The quantity held has now been reduced to 4,434 tons, composed of 4,398 tons of No. 3 quality and 36 tons of other kinds of iron deliverable as standard, and threatens to disappear altogether in the near future. Shipments of pig-iron from the port of Middlesbrough, though not heavy, are quite up to expectation. So far this month they amount to 33,668 tons, as against 25,739 tons to the same date last month, and 37,661 tons for the corresponding part of October last year.

Coke.—Local demand for coke keeps good, and values are upheld notwithstanding plentiful supply. Average blast-furnace kinds continue to realise 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is still asked for qualities low in phosphorus.

Foreign Ore.—Large supplies of foreign ore are coming in regularly, and consumers' already large stocks continue steadily to accumulate. Imports to Middlesbrough so far this month reach 133,807 tons.

Manufactured Iron and Steel.—Producers of finished iron and steel are very busily employed. They are receiving more Government work, and have considerable contracts in hand for the output of material for mercantile shipbuilding. Quotations, all round, are very firm. Common iron bars are 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; steel railway sleepers, 12*l.*; packing iron and steel (parallel), 11*l.*; and packing iron and steel (tapered), 13*l.* 5*s.*

Trade Statistics.—The quarterly returns of the Middlesbrough Chamber of Commerce, just issued, show that on September 30 of 77 blast-furnaces erected within the port of Middlesbrough 46 were in operation, as compared with 43 blowing at the same date a year ago. The production of pig-iron last quarter is given at 579,000 tons, of which 236,000 tons were Cleveland pig, and 343,000 tons hematite, Spiegel, basic and other special irons. For the previous three months the output totalled 552,000 tons, 236,000 tons being Cleveland, and 316,000 tons hematite, &c., and for the third quarter of 1915 the make amounted to 533,000 tons, consisting of 247,000 tons of Cleveland, and 286,000 tons of hematite and other special irons. Imports of foreign ore to Middlesbrough last quarter reached 668,698 tons, as compared with 605,717 tons during the previous quarter and 486,283 tons during the third quarter of 1915. The total imports of ore for the nine months of this year are returned at 1,715,436 tons, as compared with a total of 1,327,475 tons for the first nine months of 1915. The total values of goods, other than coal and coke, exported to foreign and Colonial destinations from Middlesbrough last quarter amounted to 3,172,117*l.*, as compared with 2,853,010*l.* for the corresponding period a year ago—an increase of 319,107*l.*; and the values of goods, other than coal and coke, exported during the past nine months reached 10,985,782*l.*, as compared with 6,224,104*l.* for the first nine months of 1915—an increase of 4,761,678*l.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—With the exception of superior grades, steam coal has exhibited irregularity and weakness. Tonnage conditions have become slightly better, but the arrivals have not been sufficient to admit of exports being sufficiently increased to restore strength to the market. Monmouthshires, drys and ordinaries, have been all heavily stocked, and for a week or 10 days sellers will experience difficulty in clearing trucks. The best Admiralty large steam coal has been to some extent nominal; secondary qualities have made 35*s.* to 37*s.*; Monmouthshire Black Veins, 36*s.* to 37*s.*; ordinary Western Valleys, 35*s.* to 36*s.*; Eastern Valleys, 34*s.* to 36*s.*; best bunker smalls, 25*s.* to 26*s.*; and cargo smalls, 19*s.* to 21*s.* per ton. In bituminous coal the best households have been making 25*s.* 6*d.* to 26*s.* 6*d.* per ton at the pits; No. 3 Rhondda large, 37*s.* to 38*s.*; smalls, 30*s.* to 32*s.*; No. 2 Rhondda large, 30*s.* to 32*s.*; and No. 2 smalls, 21*s.* to 22*s.* per ton. The latest quotation for patent fuel has been 40*s.* to 42*s.* 6*d.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 57*s.* 6*d.* to 60*s.*; and furnace coke, 47*s.* 6*d.* to 52*s.* 6*d.* per ton.

Western Trade Matters.—A special meeting of the South Wales Institute of Engineers was held at Cardiff on Monday for the purpose of further discussing a paper submitted in September by Mr. Budge, of the Powell Duffryn Steam Coal Company, on "Stone Dusting in Steam Coal Collieries." Mr. W. N. Atkinson, inspector of mines, said although it had been pointed out that it was not practicable to apply stone dusting to coal faces, there was no reason why haulage roads should not be dealt with, because it was by that means that explosions passed from one part of a mine to another. He entertained considerable hope of the efficacy of stone dusting in preventing serious explosions, but it must be almost continually applied.—A joint audit price policy has been refused by the South Wales Conciliation Board; it had been proposed and supported by the workmen's representatives on the ground that it was desirable to ascertain the cost of production at the collieries. Mr. F. L. Davis stated that the owners could not agree to the proposal, as they objected to having their books audited by an accountant appointed by the workmen; further, it was not possible to agree to any joint audit at the present time.—Lord Rhondda and Mr. A. Mitchelson have secured the control of the Gwcan-cae-Gurwen Colliery, which occupies an important position in the anthracite section of the South Wales coalfield; the colliery is situated in the Amman Valley, Glamorganshire; the present production is about 250,000 tons per annum, and the paid-up capital is 125,000*l.* The property has an area of about 5,000 acres. The profits in 1913 were 30,409*l.*; in 1914, 18,821*l.*; and in 1915, 29,425*l.* As regards the terms on which Lord Rhondda has acquired control, it is proposed that the fully-paid 1*l.* shares shall be taken over at 2*l.* each. The board is to be reorganised, and Lord Rhondda is to be chairman and managing director. The other directors will include Mr. A. Mitchelson, Mr. H. Seymour Berry, Mr. D. R. Llewellyn, and Mr. T. Jones; the sales agency is to be entrusted to L. Gueret, Limited, of which Lord Rhondda is vice-chairman.—The W. and C. T. Jones Steamship Company, Limited, has purchased three steamers owned by the Orpheus Shipping Company, Limited, of Sunderland. The steamers are the Beethoven, 3,752 tons net register, built in 1903; the Mozart, 4,427 tons net register, built in 1910; and the Orpheus, 4,393 tons net register, built in 1912; the terms of purchase have not transpired. For 1915–16 the W. and C. T. Jones Company paid a dividend of 25 per cent., the reserves standing at 119,000*l.* in round figures.—The directors of Baldwin's, Limited, return the profits for the past year at 315,938*l.* (after provision for excess profits tax), as compared with 228,984*l.* in 1915, 193,705*l.* in 1914, 260,383*l.* in 1913, and 202,377*l.* in 1912. The dividends for 1912, 1913, 1914 and 1915 were at the rate of 10 per cent. per annum; for 1916 the distribution was increased to 12½ per cent.; the reserve had risen this year to 133,189*l.*; in 1912 it stood at 48,825*l.*—The management of the Hazelwood Shipping Company, Limited, has been transferred to Humphries, Limited, Cardiff, of which Lord Rhondda is chairman.—The directors of the Maindy Shipping Company, Limited, recommend a dividend of 5 per cent. for the quarter ending September 30.—A special meeting has been convened of North's Navigation Collieries, 1889, Limited, for the purpose of considering a provisional agreement appointing Lysberg, Limited, selling agents.—The directors of the Haenton Steam Shipping Company, Limited, recommend an interim dividend of 5 per cent., tax free, for the quarter ending September 30.—There has been some activity during the last few days in the shares of the Rhymney Iron Company, Limited, and another important deal is spoken of as probable; no official information has, however, been obtainable upon the subject.—It is expected that Mr. W. F. Massey, Prime Minister; Mr. J. G. Ward, Finance Minister; and Sir T. Mackenzie, High Commissioner of New Zealand, will visit Bristol at the latter end of November; they will be suitably entertained on the occasion by the Lord Mayor, and their visit is expected to extend over three days, during which they will study shipping and other problems.—The Board of Trade announces that arrangements have been concluded for regulating the supply of coal from the United Kingdom to French and Italian ports in the Mediterranean. The scheme, which comes into operation on Monday, October 30, follows the lines of existing arrangements for the supply of coal to the Channel and Atlantic ports of France, which have been working since June 1. The maximum price for large coal and washed nuts is fixed at 30*s.* per ton; for washed beans, at 28*s* 6*d.* per ton; for washed peas, at 27*s.* 6*d.* per ton; and for small coal, at 20*s.* per ton.

RENEWAL OF THE RHENISH-WESTPHALIAN COAL SYNDICATE.—After a lengthy meeting (October 14), the Rhenish-Westphalian Coal Syndicate has been prolonged for a period of five years to March 31, 1922, and all the coal mines hitherto in opposition have joined the syndicate. The chairman emphasised the importance of the meeting, urging all concerned to waive their individual views in the interest of the great issues. He also stated that a war clause had been added to the agreement, according to which all mine-owners joining the new syndicate had to bring all their mines under the agreement. The question of allotment gave some trouble, and as a result of the negotiations the Westphalia, the Arenberg and some smaller concerns had their allotments somewhat increased. It must be remembered that the dealings in connection with the new syndicate, as well as those terminating in the foundation of the present temporary syndicate, have been carried on under pressure from the Prussian Government, which in both cases has made the best use of its powers granted by the Diet for the formation of a syndicate by law, if the mine-owners could not agree among themselves. It has been found expedient, and in some cases necessary, during the war to favour central bureaus for such industries as were not syndicated, and the Government could not allow a centralisation of the coal industry to be jeopardised by private differences. Hence the choice was given the coal-mine owners between a long-period voluntary syndicate or a compulsory syndicate. The coal-mine owners preferred the voluntary syndicate, although many of them openly stated that a compulsory syndicate could hardly entail a more stringent control than that which would ensue from the controlling and particular rights which have been conceded to the Crown and the Crown mines in the voluntary syndicate. Concessions were made to the Crown in almost every direction, only in the matter of the trading concerns did the Crown show some inclination to revise its original views. It is more especially in the question of the trading concerns that the new syndicate agreement differs from that of the provisional syndicate which it is to replace.

THIRD-CLASS ALL-STEEL CARRIAGES FOR THE EGYPTIAN STATE RAILWAYS.

MR. R. G. PECKITT, M.INST.C.E., CHIEF MECHANICAL ENGINEER; THE LEEDS FORGE COMPANY, LIMITED, LEEDS, CONSTRUCTORS.

(*For Description, see Page* 408.)

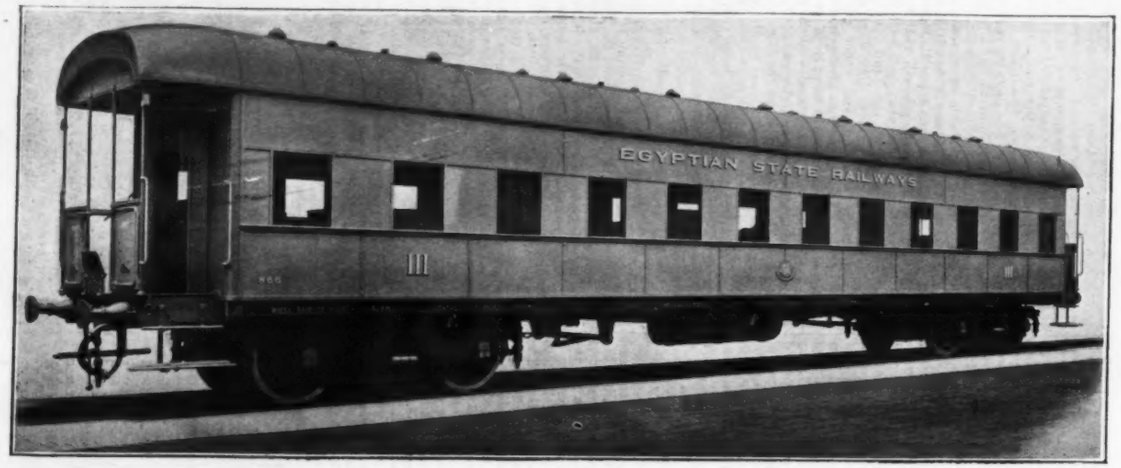


Fig. 18.

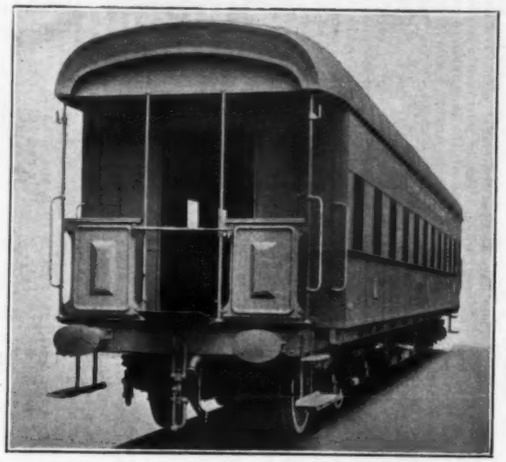


Fig. 19.

Fig. 20.

Fig. 21.

THIRD-CLASS ALL-STEEL CARRIAGES FOR THE EGYPTIAN STATE RAILWAYS.

MR. R. G. PECKITT, M. INST. C.E., CHIEF MECHANICAL ENGINEER; THE LEEDS FORGE COMPANY, LIMITED, LEEDS, CONSTRUCTORS.

(*For Description, see Page* 408.)

OUTSIDE ELEVATION — PART LONGITUDINAL SECTION

Fig. 1.

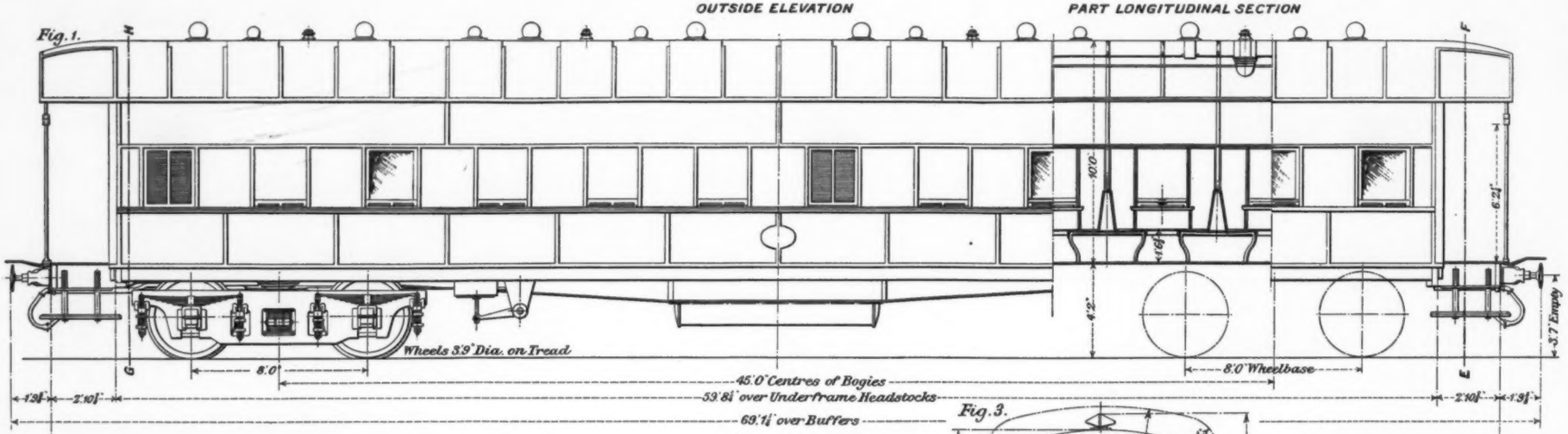


Fig. 2.

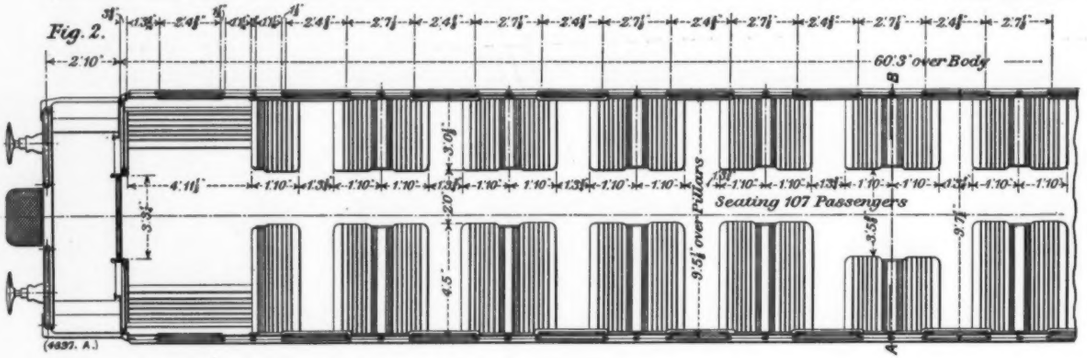


Fig. 3.

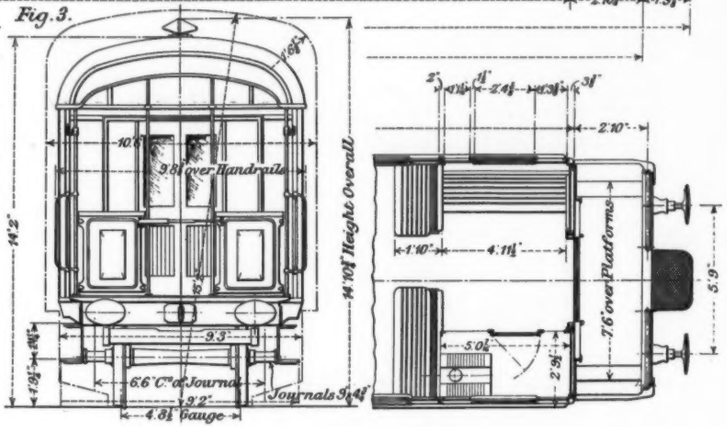


Fig. 4. SIDE ELEVATION.

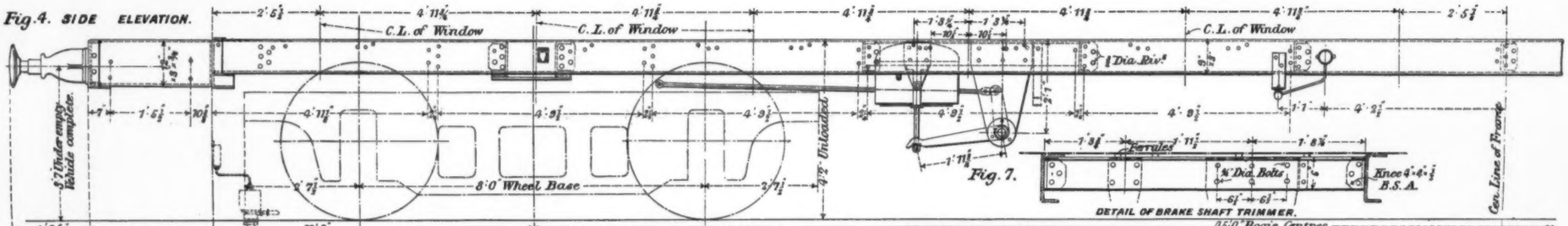


Fig. 7.

DETAIL OF BRAKE SHAFT TRIMMER.

Fig. 5.

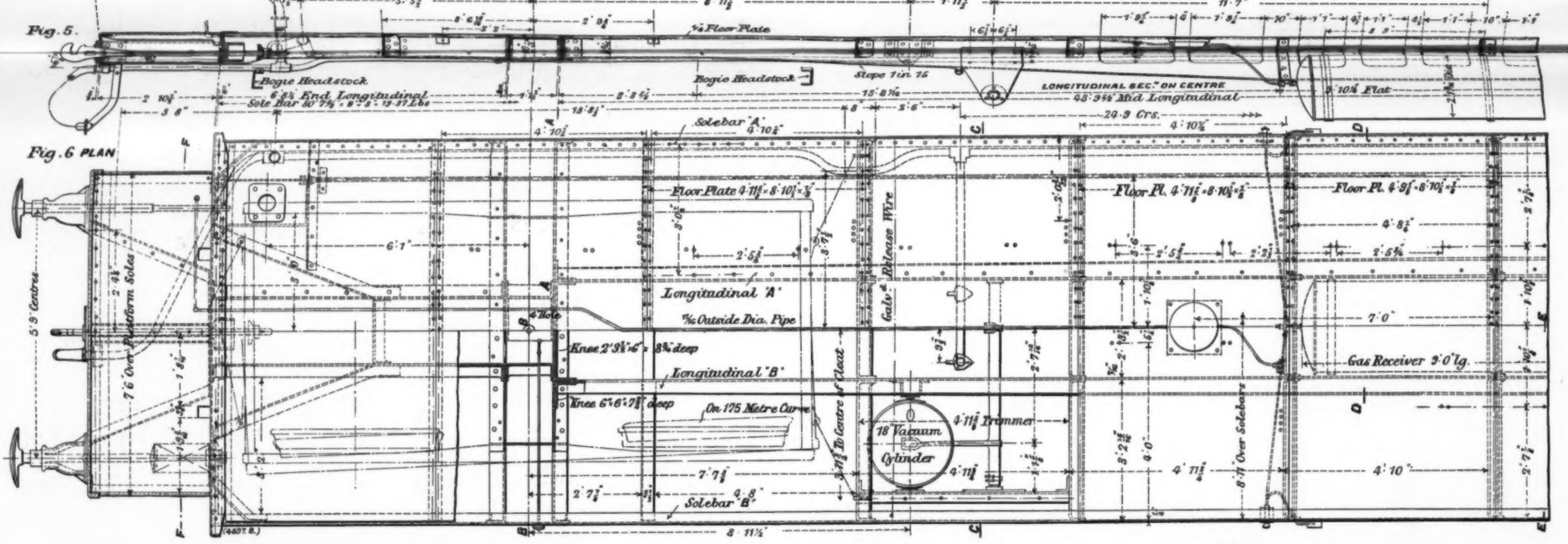


Fig. 5.
Bogie Headstock
Bogie Headstock
Slope 7 in. 76
LONGITUDINAL SECTION ON CENTRE
Fig. 6 PLAN
Solebar 'A'
Floor Plate
Longitudinal 'A'
Longitudinal 'B'
Solebar 'B'
Galv.d Release Wire
Gas Receiver 3'0"lg.
18" Vacuum Cylinder
On 175 Metre Curve
Floor Plate
Floor Pl.
Floor Pl.

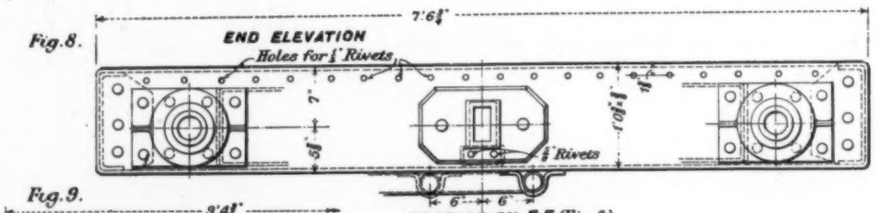


Fig. 8.
END ELEVATION
Holes for 1" Rivets
1" Rivets

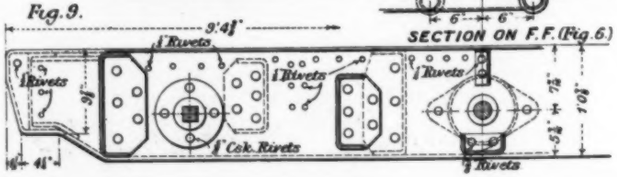


Fig. 9.
SECTION ON F.F. (Fig. 6)
1" Rivets
1" Cok. Rivets

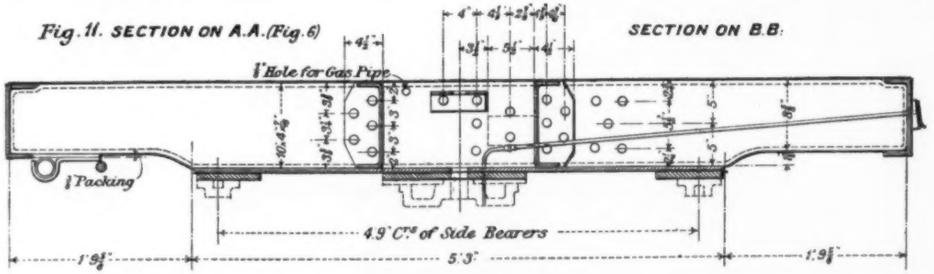


Fig. 11. SECTION ON A.A. (Fig. 6)
SECTION ON B.B.
1" Hole for Gas Pipe
1" Packing
4.9 C.rs of Side Bearers

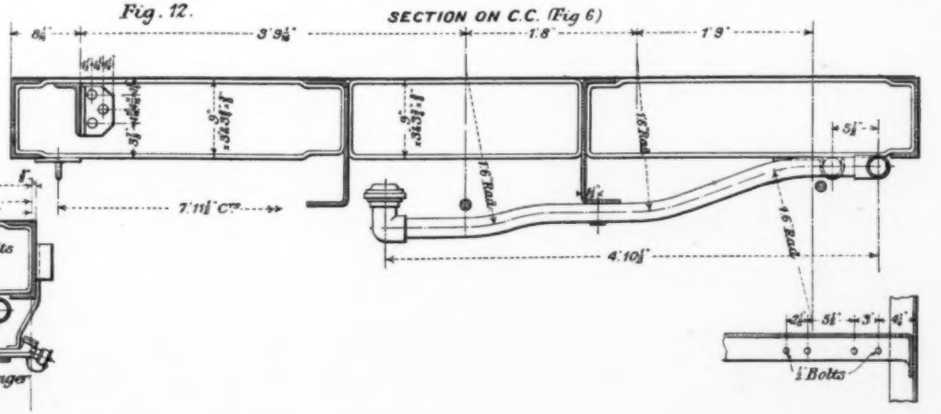


Fig. 12.
SECTION ON C.C. (Fig 6)
1" Bolts

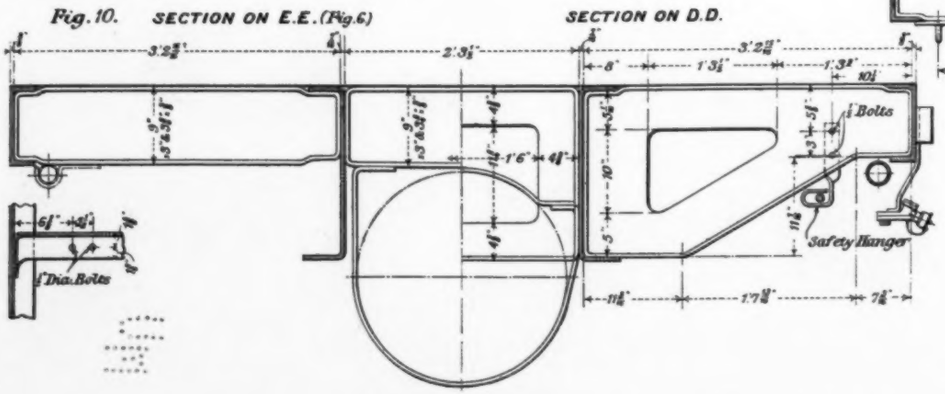


Fig. 10.
SECTION ON E.E. (Fig. 6)
SECTION ON D.D.
1" Bolts
Safety Hanger
1" Dia. Bolts

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3063 and 8508 GERRARD.

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NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 27, at 5 p.m., at the Imperial College of Science, Imperial Institute Road, South Kensington, S.W. Agenda: (1) "The Determination of the Saturation Values for Magnetism of Ferro-Magnetic Metals, Compounds and Alloys by Means of the Kerr Effect," by Mr. S. G. Barker, D.I.C., Ph.D. (2) "The Influence of the Time Element on the Resistance of a Solid Rectifying Contact," by Mr. D. Owen, B.A., B.Sc. (3) "On Diffusion in Liquids," by Mr. B. W. Clack, M.Sc.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Saturday, October 28, at 11.30 a.m., in the Corporation Art Gallery, Worthing. Mr. Frank Roberts, A.M.Inst.C.E., Engineer and Surveyor, will submit brief notes on the public works of Worthing, with special reference to tarred clinker road-work, which will be taken as read. Discussion followed by inspection of roads in the immediate neighbourhood, and visits to baths, isolation hospital, water works, refuse destructor, sewage works and fire station.

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, November 1, at 8 p.m., at the Royal Institution, Colquitt Street, when the President, Mr. Thomas M. Newell, M.Inst.C.E., will deliver his Inaugural Address.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 3, in the meeting hall of the Institution of Civil Engineers, Great George Street, Westminster, S.W., at 6 p.m. The Thomas Hawksley Lecture on "The Gas Engineer of the Last Century" will be delivered by Mr. Harry E. Jones, Member.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, OCTOBER 27, 1916.

THE GOVERNMENT AND CONTRACTORS.

THERE are broad principles of far-reaching importance involved in the controversy regarding the inquiry made and the report published by the Public Accounts Committee of the House of Commons. These, however, have been lost sight of in the public discussion, as well as in the debate on the subject in the House of Commons on Tuesday last. This is due in large measure to lack of expert knowledge by the average parliamentarian. The first, and perhaps most important, question affects the organisation of the purchasing staff of Government departments, and particularly as to whether the chief of this staff shall be an accountant or a man of high technical training and experience in respect to the purchases made. Hitherto, the Admiralty have chosen the better arrangement of placing the supervision of contract work under the charge of experienced technical officers, and it must be admitted that the results have been completely satisfactory, alike in regard to the rapidity of construction, the efficiency of the productions, and equity of the contract prices. Indeed, the most gratifying features of the conduct of the war have been the establishment of the efficiency of the Admiralty organisation and the absolute confidence which the country has reposed in the preparedness and effectiveness of the fleet. This, after all, is most convincing proof of the adequacy of the administrative conditions prevailing.

The Ministry of Munitions was formed only to supply the necessaries for the Army; there never was any question of the Admiralty organisation being other than adequate to the calls made upon it. At the outset the task set to Britain, so far as land operations were concerned, was greatly under-estimated, for easily understood reasons which need not be entered upon here. But every day brought additional conviction of the immensity of our part even in field operations. There is no need now to hide or attempt to explain away the fact that confusion resulted. Demands were made upon manufacturing resources which, in the first instance, were more imperative in respect of the date of delivery than of volume, and the firms entered into the problems of rapidity of production with whole-hearted patriotism. Additions were at once made, not only to buildings but to plant, without any conception as to the extent of their utilisation even for the war. Sound financial policy required that the consequent rate of depreciation, or rather of obsolescence, should be taken into account in determining the selling price, so that at the outset the cost of all war material was necessarily high. The Ministry of Munitions had a clean sheet to begin with, and had the advantage that as purchasers they had willing co-operation and co-ordination from sellers. They had this further and great assistance, that many men of experience were willing at once to give their services in the interests of the nation, so that it was possible to create a staff including many engineers and administrators of broad experience and special ability. It was therefore feasible to achieve in time an organisation differing from that normally at work in the other Government Departments. Moreover, they had the advantage that all producers had the one single purpose before them of acting directly for the prosecution of the war. They willingly allowed their establishments to be controlled as regards relationship with employees. They acceded to the regulations set down regarding minimised rates of profit, and yet they showed enterprise and liberal-mindedness in making additions to their plant in order to meet the rapidly increasing demands of the Ministry of Munitions, without the surety that the plant would be utilisable for peace production after the war.

When it was ultimately recognised that artillery was to play the most effective part in the war, the orders issued for shells were for millions instead of for thousands, and thus the enterprise of the engineering firms was justified. At the same time it became possible to distribute the rate of depreciation or obsolescence of the new plant over an enormously greater volume of output. Thus, automatically, the price of shells decreased. Again, it is well known to industrialists that with continuous repetition of one operation the mechanic becomes more and more deft, with the result that there is achieved for a given expenditure of machinery and of labour an enormously greater output. This influence, again, enabled the price to be greatly decreased. The same applies to the most intricate of all war material—fuzes, ordered in millions instead of thousands early in the war. And so with guns, and other engineering war productions, requiring special skill and training as well as specially devised mechanical appliances. The process of increasing the efficiency of factory work and of decreasing the cost of production was proceeding more or less contemporaneously with certain changes made in the Ministry of Munitions by reason of the acquisition of experienced officers. And yet in the investigations of the Public Accounts Committee there is no reference to these indisputable economic facts. On the other hand charges, and still more innuendoes, are made to detract from the valuable work which has been done by the great engineering firms of the country. Injustice is done, too, because all are brought under the cloud of suspicion, and that, too, without having the right to state their case at an inquiry, the full evidence of which would be published to the world.

The Government cannot dispense with such annual inquiries, because they are conducive to national economy, and it is perhaps inevitable, with our system of government, that such inquiries should be conducted by parliamentarians, without special regard for their qualifications from the standpoint of industrial experience, accountancy and judicial discriminatory ability. There is, in such committees, opportunity for that irresponsible controversial attack on capital which is so invaluable in "vote-getting." Moreover, there is the temptation to Government officials, especially those who have given their services voluntarily, to utilise the occasion for magnifying the importance of the work they have done, without reference to collateral incidents, or such changes in economic conditions as those to which we have referred. The view they put forward cannot be controverted by the "other side." Thus injustice may be done, not necessarily wilfully, but through inadequacy of light on the whole problem. It is therefore matter for consideration whether the Public Accounts Committee ought not to call in evidence from the firms against whom reflections may be made or seem to be made, or whether they should not have the help of some one who would be conversant with the technical conditions under investigation, so that there should be full scrutiny of all the facts. This is essential also as a check on the

Government Departments, because, after all, the aim of the committee is to criticize as much the efficiency of the department control in buying as the *bona fides* of the contracting firms. Unless there is such a complete inquiry, an injustice, which is foreign to the British conception of honour, may be done on every day of such an inquiry, either to Government officials or contracting firms, and that, too, without effecting the aim of testing efficiency in expenditure. Had full investigation been made, the attack on the Admiralty system of buying might not have been pursued, while more light would have been thrown on the reasons, based on sound industrial economics, why the price of shells could be reduced automatically by the enormous increase in the volume of work given out and the greater experience gained by workers in manufacturing projectiles, &c.

There is too much disposition to-day to attack the engineering firms in the country who have assisted in meeting the urgent demands of the Ministry of Munitions as well as the Admiralty. Such attacks are made with a sense of impunity, because there is an intentional vagueness about them, and because the firms are too busy to engage in newspaper controversy, apart altogether from the question whether such vague and undirected attacks can be or should be met in newspaper correspondence. The time, we hope, will come when it will be possible to measure the services rendered by these firms and the part they have played, prior to the war and during the conflict, in maintaining British supremacy: firstly, by the extent and efficiency of their great organisation; secondly, by research work and inventive ingenuity; thirdly, by their courage and enterprise in facing big financial responsibility in order to multiply many fold the facility for producing munitions; and, fourthly, by freely giving away to any firm, at the request of the Ministry of Munitions, those secrets and patents, and factory instruction, which enabled many firms hitherto inexperienced in the manufacture of munitions to undertake the production of material not only of an intricate character but requiring extreme precision. It should be remembered, too, that it was not alone to British firms that the accumulated value of research, inventive ingenuity and experience was passed. Many firms in neutral countries, who were required by the Ministry of Munitions to augment our supplies, were furnished with such invaluable data, and the time may come when those firms of such neutral countries may use such data in competition with our British factories.

Our large industrial firms and their great armies of highly-skilled and efficient workers have had a very large share in that development of the Navy which has, in very truth, been the bulwark of the fortress of liberty defended by Britain and her Allies. Without them it is impossible to believe that we could have withstood the early ordeals of battle. By their work since the war began we have been enabled to make up the enormous leeway in the equipment not only of our own army but partly of that of our Allies. No Government Department could possibly have brought to bear on the problems of munitions supply that force which has been wielded by our industrial firms. The price paid to those firms is, after all, a relatively small matter, because they are prohibited by Act of Parliament from making an excessive profit. The remainder passes into the public exchequer, so that if any undue profit has been made it goes out of one public purse into another. Thus the firms are working under great stress and with immense future responsibilities without an undue increase in profit. Notwithstanding all this, charges and innuendoes are, as we have said, made against the private firms and also against the shipbuilding and engineering officers of Government Departments without full investigation on any judicial system. All this, too, is done at a time when it is of the utmost importance to increase the assurance of our Allies that the best is being done by Britain in supplying men to combat the enemy and in equipping them with the best material that can be made in the most patriotic and disinterested spirit. The enemy is persistent in his effort to disturb that spirit of unity and fixity of purpose prevailing among the Allies: it is for us to work for its continuance in increased intensity.

THE HANDLING OF RAW MATERIALS AND MERCHANDISE.

The subject chosen for the James Forrest Lecture this year, namely, "The Development of Appliances for Handling Raw Materials and Merchandise at Ports and other Large Centres of Traffic," is one of vast importance and interest, particularly at the present time, when the shortage of labour tends so greatly to increase the delays in discharging and loading up the vessels of our mercantile marine, and thus accentuates the effect of the shortage of tonnage. In his interesting lecture, delivered at the Institution of Civil Engineers last Tuesday, and of which we commence the publication on page 420 of the present issue, Sir John Purser Griffith dealt with the subject on broad lines and in a manner well calculated to convey a clear idea of its economic importance and of its wide ramifications.

In treating of the efficiency of ports Sir John enforces the view that the power of any port to deal with traffic is not to be measured by the number of vessels which it can accommodate at its quays, but by this qualification coupled with the facilities it affords for the rapid shipping or discharge of cargoes. The capital charges involved in the conveyance of a certain amount of traffic to or from a given port are compounded of those due to the expenditure on the port itself and on those due to expenditure on the vessels by which the traffic is conveyed. Thus any reduction in the time occupied in discharging and reloading vessels increases the time available for voyages and so adds to the earning power of these vessels, while the standing charges of the harbour for superintendence, lighting and other similar expenses also become proportionately less per ton of cargoes dealt with. As pointed out in the lecture, the efficiency of a port for dealing with traffic can often be more economically increased by improving the mechanical appliances available than by increasing the amount of berthage—the latter often a very costly matter.

The handling of a cargo can be carried out by appliances on the vessel itself, by appliances provided by the port authorities, or by the two in combination, and in the lecture the circumstances which should govern the employment of the one or the other of these various systems of working are clearly dealt with. Undoubtedly the most striking economies are attained in cases where vessels are employed in a definite traffic and trade between ports specially equipped for dealing with that traffic—such, for instance, as the conveyance of coal, ores, grain or oil fuel in bulk; but while these results are generally recognised, many of our port authorities fail to appreciate sufficiently the savings which may be effected by the provision of adequate mechanical appliances for dealing with cargoes of a more miscellaneous character. The information on this point conveyed in Sir John Griffith's lecture is well deserving of careful attention.

Of course the term "handling" covers a good deal more than the actual shipping and unloading of cargoes. It includes dealing with the goods after their actual discharge from a vessel—their transfer to railway trucks or other modes of conveyance, and their storage in suitable warehouses. It has also to be borne in mind that provision has to be made for outgoing as well as incoming cargoes. This means that each berth must adjoin ample quay space and warehouse accommodation, so that when once a vessel is cleared there may be no loss of time in reloading. There are thus afforded ample opportunities for the employment of mechanical devices of a most varied character, and some of these promise to reduce in a very material degree the employment of hand labour. This is particularly the case at points such as our large railway sorting stations, where rapidity of handling is a very essential feature in successful working. The Oldham Road Goods Station at Manchester, belonging to the Lancashire and Yorkshire Railway Company, is especially mentioned in the lecture as an excellent example of an arrangement of this kind.

The handling of large quantities of raw materials such as grain, coal, oil, &c., has been vastly facilitated in recent years by the practice of transporting such cargoes in bulk, and the statistics bearing on this point, given by Sir John Griffith in his lecture, are especially striking. It is by no means improbable that with the increased use of mechanical loading and discharging devices considerable changes may be brought about in the character of the packages of various forms and sizes which go to make up a general cargo. In many cases the sizes and weight of such packages have, in the past, been fixed by the consideration that they had to be dealt with by hand labour, whereas with good mechanical appliances available more economical results might be secured by the adoption of quite different units.

The views expressed by Sir John Griffith on "Casual Labour and Under-Employment in Ports" are worthy of very special attention, bearing as they do upon an admittedly great evil and being the mature opinions of an engineer who has had a very long and responsible experience in harbour maintenance and management. Sir John says: "We have by the continuance of casual labour in our docks maintained an army of under-employed, under-clothed, underfed, and badly housed men, with their dependent families. We have, thereby, fomented discontent, and trained up a population demoralised by poverty, poor-law relief, and so-called charity, and constituting in my opinion a national danger." These are true words, and they describe a state of affairs which calls strongly for reform, and that without delay. Undoubtedly there are serious practical difficulties to be overcome, but they are not insuperable, and some of them appear to arise rather from prejudice and dislike to change than from any really solid foundation. The solution which Sir John regards as most hopeful is to form a staff of permanent and well-paid labourers at each port, to provide ample mechanical appliances for rapid discharging and reloading, and to reduce the casual element gradually. In connection with this he calls attention to what has been already done in this direction in the port of Liverpool and by the London Port Authorities. Undoubtedly the conditions are such as to necessitate very careful handling, but the goal to be attained is an exceptionally important one, and the whole question may fairly claim the most earnest attention of all concerned in the improvement of the condition of dock labour, whether they be employers or employed.

ENGINEERING EDUCATION AFTER THE WAR.

One can scarcely take up a newspaper without finding references to British inefficiency. We are told that we are inefficient as business men, inefficient as manufacturers, inefficient as engineers, inefficient as parents, and inefficient in science. Many remedies are proposed, and numerous committees are debating them. What the outcome will be it is impossible to say, but it needs no discussion to show that the most pressing necessity is to make ourselves efficient as individuals. If that can be done all the rest will be easy. Half our troubles during the war have arisen from the difficulty of finding men to fill the various posts which have been created. New wants have arisen, but we have been very slow to understand them, and still slower in finding men to deal with them. This applies to all strata of activity; but here we are concerned only with the engineer. Fortunately we have learned much politically, socially and technically, but it is undeniable that a nation of efficient individuals would have reached our present stage in much less time than we have done. Much delay, it must be admitted, has been due to a want of technical knowledge and breadth of outlook in engineers and their staffs. Many of them have begun to see that not only were they wanting in adaptability, but that their manufacturing processes, with which they were quite content, ensured neither accuracy nor output. Even if they were dimly conscious of this before they felt helpless because of the scarcity of men able to carry through reforms in shop practice, not only for want of technical knowledge, but more particularly from inability to deal with the active and passive opposition which the introduction of new methods always arouses. The supply of efficient subordinates was quite inadequate, and therefore the introduction of more efficient plans was a practical impossibility. It needed a war, such as the world has never before seen, and the temporary suspension of all economic laws to provide the motive power for the necessary effort.

The war, however, will not continue indefinitely in its present form, but within a comparatively short period will give place to a commercial contest in which the economic laws will again become supreme. That struggle will not be measured by years but by generations, and in spite of all that can be done by legislation and tariff agreements, the most efficient nation will win. Natural advantages will count for something, but individual efficiency will be the controlling factor, and unless we alter our methods we may easily find ourselves in an inferior position. The subject is too wide for complete discussion in these columns except in relation to engineering matters, but as mechanism underlies the whole system of manufacture and distribution, the field open to us is more than ample. Since efficient methods and processes must all be founded upon individual efficiency, it is clear that improvement must be sought, in the first place, in our educational systems. Already teachers of all kinds are discussing improvements and alterations, but many of them are much in the dark because they know so little of the demands of commerce and manufacture, and when they make inquiries from practical men they find that these know little about educational methods, and so cannot give them direct assistance. Occasionally they meet with greater success, as did the Association of Technical Institutions last week when they asked Sir Trevor Dawson, a managing director of Vickers, Limited, to give them his views on education after the war, with special reference to engineering. They could not have carried their difficulties to a better source for solution, for Sir Trevor is not only an inventor and engineer, but he is also a man of affairs who thinks in terms of armies and navies and millions of capital. He is equally at home in science and business, and in the art of dealing with men. He told his hearers frankly that he was not an expert in curricula and must leave all details to them. What he did was to limn in broad outlines a course of education and training which would produce the type of man of which engineers are in urgent need.

Prominent among the subjects of study he put the "humanities." We are apt to connect these almost exclusively with Greek and Latin, but Sir Trevor did not use the word in that restricted sense. The humanities are studies which widen the pupil's knowledge of his fellow men, which bring home to him the truth of the proverb *Savoir tout, c'est pardonner tout*, which render him helpful towards weakness, patient towards dullness, sympathetic towards misfortune, forcible towards idleness, and resolute in action. There is a whole range of studies, including specially, of course, poetry and history, which conduce to this end. And we would not exclude science from them, if it be properly taught. Unfortunately much technical instruction is intensely narrowing. The student contracts intellectual myopia, and comes to despise anything which is not capable of definite statement either by figures or a formula. Demonstrators in colleges are often appalling examples of the effects of a constant application to the details of scientific study without the widening influence of imagination. That is the reason why men are selected for professors on account of their achievements and not for their ability as teachers. It was difficult to learn from the late Lord Kelvin; but it was impossible to hear him speak without being conscious of an intellectual uplifting that raised the veil from the secrets of nature, and if it did not disclose them in detail, at least revealed their vastness and dignity, and made the hearer conscious that he was an actor in a drama that could not be played in a test-tube or weighed in balances. Men like Lord Kelvin are scarce, but we still have professors with imagination who can make science sound like a romance and who can carry their pupils to the hilltops to watch the dawn of new ideas.

Sir Trevor Dawson recommended the humanities because engineers have always to rub shoulders with other men, and have to depend largely on associates and subordinates to carry out their ideas. But he did not regard book knowledge as sufficient, and therefore he suggested to the teachers before him that the youth who is to be an engineer or industrial worker cannot too soon be brought into contact with working men and workshop practice. This, of course, involves some kind of sandwich system. Boys now leave primary schools at the age of 14, after a certain amount of instruction, but with very little education. It is clear that they must still be taught many subjects, and if they are at the same time to learn workshop practice, school and work must alternate. Sir Trevor would practically double the number of pupils in a works and run them in two shifts, one being in class and the other at the bench or the machine. This is not an arrangement the old-fashioned works manager would welcome, but after the war he will have to put up with many things he does not like. However, it would not extend to all his boys for long, for every year there would be a drastic combing-out of the unteachable. A board school teacher once told the writer that only one-third of his scholars were really able to make progress, so the rejections at the end of the first year are likely to be numerous.

Those who survived the first examination would go on for another year, in which account would be taken of conduct and aptitude both in the works and in the class. An opportunity would then be afforded to each boy of reconsidering his career in life, and he would be permitted to try some other if he wished. There are very few youths who would not be the better adapted for nearly every occupation by reason of two years spent at engineering, both practical and theoretical, and by intimate contact with working men.

The second selection would still further reduce the number of candidates, while those who survived the inquisition into their third year's conduct and attainments might fairly be regarded as having the makings of really efficient engineers in them. A technical college or university would then continue their education for two more years, and thus there would be provided for the works, without further selection, and almost in the correct proportions, the privates, corporals, sergeants, second-lieutenants and lieutenants, and the higher officers necessary for the industrial force, provided, of course, that the teaching had been of the right kind.

Sir Trevor Dawson laid this curriculum before the teachers as the ideal means of filling our engineering works with men efficient in all the different stages from machine minding to management. Undoubtedly this is the correct method to pursue—to lay down the ideal in the first place, and then to devise the means of attaining to it as nearly as circumstances will permit. It is clear that such a course would entail sacrifice—for a time—for all concerned. The works owner would find his routine upset by the coming and going of the boys, the parents would lose their sons' earnings or part of them, for it is clear the manufacturer could not pay much, if anything, to youths who only worked half their time, and the taxpayer would have to provide the instruction and possibly something towards subsistence. These conditions could not, of course, be restricted to engineers. Boys who chose to be chemists, or builders, or manufacturers would have an equal claim for assistance in climbing the ladder of life. On the other hand the gain to the community would be very great, and we might look forward to the coming commercial struggle with confidence. At the present time Sir Trevor's scheme may be a counsel of perfection, but it was endorsed at the same meeting by Lord Haldane, who stated that the nation was entering upon a critical period of its history. The first step is to convince the public of this and to show them that the present war is only an episode in a greater struggle, and that just as we are making great sacrifices to win the first victory, so we must make others to consolidate our position for the future. The scandal of boys entering blind-alley occupations by thousands will have to be put an end to in some way, and it must no longer be possible for a youth of 20 years of age to find himself without a trade or with no knowledge greater than that required to read a halfpenny paper and believe all he reads. The individual liberty which we have regarded as our birthright has been tried and found insufficient for our needs, and compulsion will have to be applied to youths of the working classes, just as it has always been to young people of the middle and upper classes.

An ignorant man is a clog on the community, and cannot be tolerated in the future. But all this will require time and constant iteration. As Mr. L. A. Legros said in his excellent and interesting presidential address to the Institution of Automobile Engineers a fortnight ago, "In a great democracy time is necessary for the education of the mass, but when the education has been given on a sound basis it may reasonably be hoped to be of permanent value and effect." In this case it is not the lower class that will need educating so much as the middle class. The working man will possibly lose something by his sons' earnings being reduced for a few years, but he will have the satisfaction of seeing them prepared and fitted for the best posts that they are capable of filling. We have been told *ad nauseam* of the hopelessness and monotony of the workman's career, but we believe that it now offers greater possibilities than ever it did. The middle classes are becoming more and more infertile; in the lists of fallen officers the number of only sons is most striking. On the other hand the percentage of "black-coated" men in a works increases from day to day, until in some American works it forms 10 to 15 per cent. of the whole. Very many of these must be recruited from the working classes, and Sir Trevor's system would furnish a ladder upon which great numbers of capable boys might climb far above the level attained by their fathers. To the middle classes this would be no immediate gain; they would have to wait for their profit, but it would come in good trade, in high rates of interest, and in general prosperity. There can be no better investment of the national capital than in converting ignorant, heedless boys into efficient men capable of grappling with the social and technical problems which are already plentiful enough, and which are more likely to increase than to diminish in the future.

WORKS ORGANISATION.

It is a happy augury for the future of our industries that the problems of works organisation are being tackled with greatly increased earnestness. The title of this article embraces the whole field of industrial and commercial activity and the rearing of future workers, since arrangements must be made for training not only the manufacturing engineers, but those who are to take part in the equally important business of accountancy and selling. It is satisfactory, therefore, to record that at the meeting of the North-East Coast Institution of Engineers and Shipbuilders last night three related papers of a most suggestive character were read, dealing in a thoroughly practical way with almost every phase of works organisation; and it is to be hoped that there will follow to-night a discussion yielding thoroughly practical suggestions, so that the whole profession will be assisted towards the improvement of works organisation. Such improvement is much needed, either as a whole in some establishments or in respect of neglected yet vital details in others, and the time has come when there should be freer interchange of views and experience, because the effort to improve our trade relations must be regarded from the national rather than the individual standpoint.

The first paper, that on "Manufacturing Organisation," was read by Mr. A. D. C. Parsons, a nephew of the inventor of the steam turbine. In it there is worked out in considerable detail two schemes applied with much success, the one in a turbine manufacturing works, and the other in a factory dealing with purely standard products. While there is much similarity in the general principles applied in both types of factories, there is necessarily great variation in the details. The aim is, of course, to ensure that there will be the maximum production from the plant, in order to lower overhead or establishment charges and cheapen production. To begin with, therefore, Mr. Parsons enforces the view that the draughtsman, in building up his production on the drawings, must have an eye to facility of machinery and manufacture and to the elimination of that which may involve difficulty. Another important point, not always remembered in the drawing office, is the specifying of materials and details which are known to be kept in stock. A dominant consideration in the factory, as well as in the drawing office, is to ensure that the work progresses without any loss of time from any cause, and there is given in the paper interesting

suggestions and typical diagrams, so that from stage to stage it can be ascertained how the progress conforms to the predetermined estimated rate in order to ensure the delivery date being kept. These estimates are tabulated for each unit in a factory which, for instance, produces turbines, or for a given number of units where standard articles are manufactured for stock or export. Beginning with the date of delivery and working backwards, the estimated rate of progress is determined and the general time-table of manufacture is ever present to all responsible for progress. This, although only an approximation, ought to be fairly accurate when based upon past experience, and any surplus time which the date estimate when completed may reveal can be apportioned to departments where there is possibility of congestion.

An examination of the record of the actual progress in comparison with the estimated dates when revealed, either on tables or on diagrams, has the further advantage of showing whether the machine tools are being utilised according to their rated speed of production. In the majority of works each machine tool is rated at a certain figure per hour depending upon the capital expenditure on the tool, and since all work done on any particular tool is charged at that rate per hour, it is important that there should be this check. Diagrams are, therefore, reproduced showing as ordinates such units as pounds, horse-power, kilowatts, or number of machines, or the machine time per week, the standard figure being based on the money invested in the machine, while abscissæ show periods of time. Again, as each important unit of the manufacture is recorded in the table showing the progress in the drawing office, pattern shop, foundry and machine room, it is easy for the foreman to ascertain the progress of the respective units and thereby hasten the laggards. This, it may be contended, involves a considerable clerical effort, but the result, from the point of view of speed of production, economy of manufacture, and also in checking the cost, counterbalances the effort and cost involved. It is manifestly superior to the haphazard way, too often applied in the past and still maintained in many factories, of the foreman relying largely, if not entirely, on his own observation. Mr. Parsons, it will be seen, by producing his typical diagrams and tables, has done great service to those who wish to systematise manufacturing organisation.

The second paper on the subject was devoted to the financial organisation of factories, and was read by Mr. Edwin L. Orde, a vice-president of the Institution. Here again the diagrammatic method is exemplified, the author's aim being to enable the management to keep an easily read record of the comparative actual and estimated cost for the period of the contract for such work as renders such data possible. It is too late to discover that the estimate has been greatly exceeded when the contract is completed, although even then a firm may profit in succeeding contracts by the experience gained; but then it is not always easy to arrive at a definite conclusion as to exactly where the loss arose, or where the mistake was made in preparing the estimate. The days are past when such mistakes can be made with impunity. Mr. Orde is all in favour first of those preparing the estimates having technical knowledge of the work they are engaged upon, because such a technical staff can be occupied also in watching net costs as the work progresses, and in devising means whereby they can be compared with the estimates at all stages, so as to keep the management closely in touch with the financial aspect of the operation. He thinks, further, that the foremen should be involved in the time-keeping system to an extent which will influence them in spreading the work as evenly as possible, so that a man on time rate may not be employed on a number of comparatively short operations for various orders, whereby accurate record of cost becomes difficult without excessive expenditure upon analyses. As regards the question of indirect charges, Mr. Orde seems to be inclined to the view that these charges should be calculated for net cost and estimating purposes on the labour cost rather than on the total cost of labour and material. He instanced the case of two sister ships, one plated with ordinary steel and the other with galvanised steel. The actual labour cost and works expenditure account to be covered by establishment charges, he pointed out, would probably not show any very large difference between them, but the percentage on the sum of labour and material costs for the ordinary steel ship would yield a sum substantially less than in the case of the galvanised ship. On the other hand, where contracts are placed on a time and material basis, it is probably a benefit to purchasers to fix charges on material and labour, as this gives them an inducement to check extravagance in the choice of material. The subdivision of charges is another question where there is great diversity of opinion. Mr. Orde stated that in engineering works where a large amount of work is done on machine tools, it was probably advisable to charge all such capital costs items under a special heading, and provide for them by fixing a rate for each machine, which is added to the cost of all the work which it produces. The extent to which this should be carried, how far shop charges should be kept separate from establishment charges proper, whether it was advisable to separate shop and department from distribution and general charges, and many questions of such nature, could only be decided by the exigencies of the particular business which was in question, but it seemed to him that the greatest accuracy might be expected where the items under direct charges were many and those under indirect charges were few, and that the best facilities for scrutiny by the management would be provided if subdivision were carefully made on this line.

Another phase of the subject of financial organisation was that associated with what has come to be termed the trade banking question. Mr. Orde was all in favour of such trade banks, assisted by the Government, not only for the direct benefit but for the organisation which would be created in association with them for the propagation of commerce in foreign countries. Such an organisation should be a combination of banks, merchants and manufacturers, supported by the Government financially if necessary, and through international channels whenever and wherever required, but not under Government control. Some of the details of the work to be carried out by such an institution were enumerated by Mr. Orde as: "(*a*) Translation into the particular language and numeral system of communications between buyers and sellers, in fact, of all the literature of the trade; (*b*) the dissemination in the proper direction of all such information as may spread full knowledge of the productions of firms involved; (*c*) the collection of information regarding the requirements and standing of possible purchasers; and (*d*) the training and development of suitable men to act as pioneers of British trade, who shall have sufficient technical knowledge to appreciate possibilities, understand and overcome difficulties, and sufficient standing to be entrusted with powers to negotiate contracts if necessary."

The third paper dovetailed into the others very fitly, as it dealt with the subject of selling organisation, the author being Mr. G. H. Tweddell. It was full of useful hints to those engaged in this important department of works organisation. While the paper sketched with considerable detail a typical selling organisation, its value rested rather on the hints for the achievement of success. The author enforced the view which we have time and again urged that selling representatives ought to be men of high technical knowledge, as well as being gifted with those special qualities required for men "on the road." As he pointed out, the selling engineer—because he must be an engineer—should be able to answer questions, to give advice, to take particulars, and, in cases of necessity, to prepare an estimate and conclude a contract on the spot. Sound technical knowledge and a considerable practical training were almost indispensable, especially in the many-sided electrical industry with which he was concerned, and for which he traced out the ideal selling organisation.

NOTES.

The Quebec Bridge Accident.

We learn from *Engineering News* of October 5 that careful measurements have now been made of the chain hangers from which the central span of the bridge was hung at the time of the disaster. These chains were built up of slabs 30 in. wide by $1\frac{1}{2}$ in. thick. The material was carbon steel. Including an allowance of 20 per cent. for impact, the average stress on the material on each side of the pin holes was intended to be 20,000 lb. per square inch, which, if the material were perfectly elastic, would mean a maximum stress at the edges of the pin holes of three times as much. The examination now made shows that each 30-ft. link of the hanger which carried the corner of the span where the failure originated has stretched $\frac{1}{16}$ to $\frac{1}{8}$ in., whilst the stretch on the companion chain at the opposite corner was $\frac{3}{8}$ to $\frac{5}{8}$ in. per link. The elastic limit of the material used is stated to be 27,000 lb. per square inch. These measurements show pretty conclusively that the blow consequent on the failure of the rocker was relatively slight and confirms the conclusion arrived at from other evidence that the bearer girder on which this rocker was carried was knocked aside by the fall, rather than struck a direct blow. The immediate result of this was that the whole load due to one-half the span was instantaneously transferred to the companion hanger. The text-books show that if a load be applied suddenly, but without impact, to a structure, the stresses produced will be double those due to a static application of the load, and hence if the material of the hanger remained perfectly elastic the stress carried would be three times as great as provided for. Actually owing to the plastic deformation of the material the intensity attained would no doubt be considerably less, but it is estimated that the excess was at least 60 per cent. This, it is of interest to note, was carried without injury by the rocker at this corner of the bridge, and shows pretty conclusively that the failure of its companion must have been due to a hidden flaw.

The Composition of the Upper Atmosphere.

In discussions concerning auroræ, the propagation of sound through the atmosphere and zones of silence, and meteorological and astronomical phenomena it is frequently assumed that the air does not merely become more and more rarefied, as greater heights above the earth's surface are reached, but that its composition also changes. The heavier elements are supposed to be confined to the lower strata, whilst hydrogen and helium, hardly recognisable by ordinary analysis in the air we breathe, are assumed to predominate in the higher strata. There is very little observational evidence to support that assumption, though it sounds plausible. The difficulty is to collect air samples of sufficient bulk at great heights. Unmanned balloons (*ballons sondes*) have been sent up to 12 km. and greater heights; but these balloons can barely carry the automatic instruments which record the temperature and pressure, and could not be charged with bottles and with automatic devices to open and to close those bottles again. Free balloons have lost in favour since man has learnt to fly, and flying machines have rapidly developed into war machines. Some day they will possibly be utilised for scientific purposes. In Europe the exploration of the upper air is interrupted for the present, and even the working out of material collected before the war is interfered with. In 1911–12 Professor A. Wigand, of Halle, made four balloon ascents from Bitterfeld up to heights of 9 km. (6 miles) and collected 11 samples of air in bottles apparently of suitable construction. They were cylindrical glass vessels of 2 litres capacity, each ending below in two narrow glass tubes provided with stout walls; one of these tubes was sealed after examination, the other was fitted with a three-way cock to which a long tube of aluminium could be attached. This tube had a length of 30 m. and an external diameter of 7 mm.; the tube was built up of 20 sections, which were screwed together when wanted. By the aid of a small rubber balloon the air was sucked through the tube, the tap was then turned, and the air admitted into the glass bottle, which was afterwards closed. The use of the tube and other measures prevented contamination of the air collected with the carbon dioxide exhaled by the aeronauts and any hydrogen escaping from the balloon. The analyses were to be performed by Professor E. Erdmann by his method of fractionated condensation. Only four analyses could be made before the war broke out, however, and as

the completion of the work looks doubtful, the preliminary results were published in the *Physikalische Zeitschrift* of September 1, 1916. Fortunately some further data were available. When Halley's comet approached the earth in 1910, balloons were sent up from the observatories at Lindenberg and at Vienna, and 21 samples of air were collected; some of these were also analysed by Erdmann. The analyses consisted of determinations of the carbon dioxide and of the gases helium, neon, hydrogen, and, further, of spectroscopic tests for hydrogen. The results do show that the upper layers of the atmosphere contain less carbon dioxide and more of the other gases mentioned than the lower strata. The carbon dioxide content decreased from 294 to 277 cub. mm. per litre, and that of the lighter gases increased from 22.8 to 33.7 cub. mm. per litre, when the height of 9 km. was reached. The assumption is thus confirmed that the diffusion in the higher strata is not the same as in the lower strata, and that the heavier gases tend to concentrate near the earth's surface, while the lighter gases accumulate higher up. But there is not sufficient material to draw any further conclusions, and the observed intensification of the hydrogen line in particular would not justify the assumption of a hydrogen atmosphere. Two litres of gas make up less than half a gallon, and that is a very small volume for the analytical determination of traces of gases.

The Journal of the School of Technology, Manchester.

Institutions like the Manchester Municipal School of Technology, being intermediate between the university or technical college and the evening school, it will be thought, should afford the happy medium for the training of foremen and skilled operators. As a matter of fact, the School of Technology, which was founded in 1824 as the Manchester Mechanics' Institution, claims university rank for those of its students who enter suitably prepared for the three years' university course, and so far as this department of the school is concerned, the school is actually a part of the University of Manchester; the student is a member of that university, and may take his degree as B.Sc.Tech., and after a fourth year as M.Sc.Tech., in the school. There are, in addition to the university courses, part-time (mostly evening) classes for people occupied during the greater part of the day. The Journal of the School of Technology for the year 1914, however, which we have received, deals exclusively with research work done in the school by students in the above sense. Most of the industrial research is conducted in co-operation with firms of the district. The small quarto volume of 264 pages contains accounts of researches in the domains of radiation, engineering (elastic properties of steel, lathe finishing tools, boiler practice, sanitation), textiles and dyeing (historical and practical), gaseous explosions, chemistry, &c. With very few exceptions these researches have already been published in the journals of the learned and technical societies to which they were presented, and we do not quite see why the heavy expenditure of reprinting these papers in the journal of the school should be incurred in these days. Of the few unpublished researches we may mention a note by Mr. F. S. Sinnatt and Mr. J. Wallwin (of Messrs. Wallwin and Co., Salford) on industrial gas burning. Producer gas, for laundry irons and metal melting, *e.g.*, it is pointed out, is frequently burnt under conditions where the dangers of poisoning by the carbon monoxide in the gas and by the gases of combustion can only be mitigated by efficient ventilation. Mr. Sinnatt found 100 ironers working in one room, each handling a gas-iron burning more than 6 cub. ft. of gas per hour. To ensure good combustion, the gas is mixed with air under slight pressure, and as the explosive mixture is apt to flash back, the gas jet is made to burn over thick wire gauze or a perforated screen. The fine jets into which the flame is split up then tend to spread outward, however, so that gas escapes unburnt. This is particularly noticeable when, in the course of time, some of the perforations clog up and others widen out owing to the oxidation of the wires. The flame is then no longer uniform, but consists of long and short jets, and some of the latter may be cooled by the metal they are to heat and become extinguished. Mr. Sinnatt makes the screen—generally a disc fitting the burner—cup-shaped or dished, and provides it with oblique perforations, such that all the little jets converge to one focus or to several foci in the same vertical. The flame is conical, there is no lateral spreading, and the good mixing of air and gas in the central portion of the flame ensures efficient combustion. This device is patented. A contribution by Mr. J. S. Peachey on catalytic acceleration of the vulcanising process also concerns a patented improvement. By adding certain nitroso-derivatives, especially $\frac{1}{2}$ per cent. of paranitroso-dimethylamine, to the mixture of rubber and sulphur before heating, Mr. Peachey reduced the vulcanisation period to one-third; compounds of aldehydes and amines were also found effective, whilst phenyl hydrazine distinctly retarded the vulcanisation. A third, longer, communication, by Mr. H. G. Bell, deals with the commutation of large continuous-current generators and rotatory converters under heavy overloads. Interpoles, Mr. Bell points out, incline to arc when their iron is saturated. To overcome this difficulty he divides all his commutator brushes, each brush consisting of two halves lightly insulated from one another. The trailing half-brush is joined to the coil of the commutating pole, this winding being of twice as many turns as in ordinary practice; the leading brush is connected to a resistance called the diverter; beyond, the two branches are joined to the main circuit. By these means Mr. Bell made his dynamos bear up to nine times the full load.

Electric Steel.—The United States Steel Corporation have two 15-ton Héroult electric furnaces installed at Joliet, Illinois. In these metal from the open hearth or from the converter is further refined.

The Optical Analysis of Stress.—A paper on the above subject, describing his investigations made by means of celluloid models, was read before the Optical Society last week by Professor E. G. Coker, F.R.S.

American Electric Railways.—For the first half of this year the American Electric Railway Association reports a noticeable improvement in the electric traction business of the United States. The Association deals with 7,444 miles of line, and statistics which it has collected indicate an increase in working charges of 8.08 per cent.; an increase in working expenses of 5.68 per cent.; and an increase in net earnings of 12.10 per cent.; the totals being 100,582,214 dols., 61,644,132 dols. and 38,938,082 dols. respectively.

Science and Industry.—The 60th session of the Institution of Engineers and Shipbuilders in Scotland was opened on Tuesday by a short address by the president, Mr. W. W. Lackie, and promises to be most successful. The president referred to the thoroughly healthy state of the institution, and stated that 165 members had joined the colours, while practically all others were engaged on war work. Dealing with topics of current interest and the changes effected during the past 12 months in the attitude towards national affairs, Mr. Lackie referred to the interest which science and industry had begun to take in each other. He continued:—When we hear that four German firms employ as many analytical chemists as there are in Britain altogether, that individual firms in America spend 100,000*l.* per annum on research work, while the annual indebtedness to the national purse of our National Physical Laboratory is some 7,500*l.*, that entire industries have been snapped up by our competitors because of our neglect of science, we feel—we cannot but feel—that the time has come for a drastic revision of the attitude of industry to science. As engineers and as business men we can ascertain and to some extent measure the significance of the results which have been obtained, especially in Germany and in America, from liberally endowed scientific research. This revival of interest in the practical possibilities of pure science will, in due course, be bound to have an entirely desirable influence on the attitude of scientific men to industrial processes. Knowing that the men in charge of our workshops and factories are now likely to welcome with open-minded eagerness any suggestions for improvements in industrial and manufacturing processes which may come to them from the laboratory, the men of pure science will be the more likely to pursue their patient labours to a successful issue. I hope and believe that after the war we who belong to the practical side of engineering will do our best to see that men who have shown themselves to be possessed of exceptional aptitude for scientific research will be encouraged to pursue their natural bent. I trust that in our general revaluation of pre-war standards we may see our way to appraise the worth of a man with a talent for scientific work at least at as high a price as we are prepared to pay for a successful insurance agent. In any case I am convinced that one of the most hopeful signs of the times is the growing belief in the application of science and scientific method to industrial processes and to industrial organisation.

LITERATURE.

Aeronautics: First Annual Report of the National Advisory Committee. Washington: 1916.

First Notice.

The United States last year followed the precedent set previously in this country by appointing a National Advisory Board for aeronautics. As with us, the members consist in the main of non-officials, but of men of recognised eminence in the scientific and engineering worlds. The chairman is General G. P. Scriven, and the secretary, Naval Constructor H. C. Richardson. The work of the committee has, it is stated, been hampered by the lack of suitable premises, but, nevertheless, their first report, just issued, contains much of great interest and great value, which will well repay careful study. Two important papers dealing with the behaviour of aeroplanes in gusts are included. Of these the one describes careful model experiments made in the wind tunnel belonging to the Massachusetts Institute of Technology by Mr. J. C. Hunsaker. The model was a reproduction on a scale of $\frac{1}{24}$ of a high-speed military biplane tractor known as Curtiss J.N. 2. The wind tunnel and the aerodynamic balance used were duplicates of those at Teddington. The lift, drift and pitching moment of this model were measured for a series of angles, sufficient data being obtained to make it possible to calculate the "derivatives" required in the complete theory of longitudinal stability in still air. The damping factor was also determined experimentally. The principal result established was that the stability of the machine fell off rapidly as the speed diminished or the angle of attack increased, although at high speeds the model was very stable. It is suggested that many accidents to military aeroplanes when travelling at low speeds find their explanation here.

The second paper is a mathematical discussion of the theory of an aeroplane encountering gusts. A new point brought out appears to be the powerful effects which may arise fram a rotary gust, such as may be met with when machines flying low meet air sweeping over the ground and set in rotation thereby.

In another report the suitability of the Pitot tube for use as an aeroplane anemometer is discussed by W. H. Herschel and E. Buckingham. One conclusion reached is that although a correction for the compressibility of the fluid is theoretically required, this only amounts to 0.5 per cent. even at speeds as high as 130 miles per hour, so that in practice the correction is negligibly small in comparison with the unavoidable errors of observation.

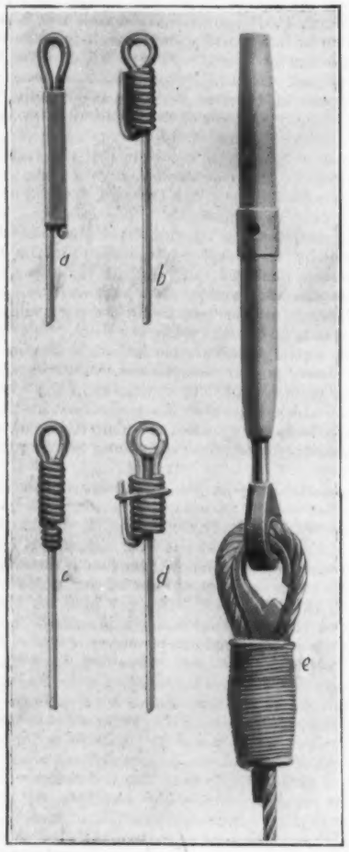
A very valuable and interesting note on the strength of fastenings for aviation wires and cables is contributed by the John A. Roeblings Sons Company, of Trenton, N.J. Various fastenings for solid wires were tested to destruction and the strength of the joint found expressed as a percentage of that of the plain wire. The lowest figure found was 59 per cent. and the highest 95 per cent. It is stated that the commonest practice (in America presumably) is to form an eye or loop in tinned aviator's wire, and a ferrule is made by wrapping a thin flat strip round the loop. The free end of the loop is bent back over the flat ferrule holding it in place, and the whole dipped in solder. The arrangement is shown at *a* in the engraving overleaf. This fastening is said to be unsatisfactory, its strength being low and variable. Moreover, the fastening must be factory-made, being unsuitable for quick and rapid repairs in the field. The report states that the standard terminal in Europe is as shown at *b*. It consists of an oval ferrule made of spring wire, applied in the same way as the flat ferrule in *a*. In making it great care is taken that all the bends have the same radius of curvature. The spring quality wire used for the ferrule is of the same diameter as the stay wire, and the complete ferrule consists of nine turns. Both it and the main wire are tinned, but no solder is used. The free end of the loop is simply bent back over the ferrule. On test the average strength of this joint was found to be less than 65 per cent. that of the solid wire. Failure generally occurred by the free end drawing through the ferrule. Improved results were

obtained by wrapping the free end of the loop round the main wire as indicated at *c*, the efficiency rising to 72 per cent.

The most efficient form found is represented by *d*. Here the wire is bent into a double eye. There is a wedge bearing on this eye, and lying between the main wire and the free end. The ferrule is of spring quality wire, and the free end is turned up over it and tied back as indicated. No solder is used. The efficiency of this joint is 92 per cent. to 95 per cent., the average being 94 per cent.

For fastening stranded cables, a thimble is spliced into the end. The efficiency is 100 per cent. in the smaller sizes and 90 per cent. in the larger sizes. For field repairs the arrangement shown at *e* is recommended. It is 90 per cent. as strong as the cable. A somewhat similar plan can also be adopted with equally satisfactory results for solid-wire attachments.

An interesting note on fabrics for dirigibles is contributed by the Goodyear Tire and Rubber



Company, reasons being advanced for the conclusion that a 5 per cent. reduction in the weight of the fabric would be cheaply purchased by an addition of 20 per cent. to its price. The results of some experiments on balloon fabrics are given in another paper, by W. A. Gibbons and O. H. Smith, who find that the permeability increases rapidly with the temperature, the rate of increase being 4 per cent. per degree C. They found also that tearing tests showed the great superiority of bias over parallel doubled fabrics.

The same experimenters have also studied fabrics for aeroplane wings. So far as their investigations go they indicate that fabrics coated on the one side with rubber and doped on the other tighten satisfactorily and would probably resist damp weather. For maximum efficiency fabrics should, they say, not be stretched too tightly before doping. Linen appears to be the best fabric, most of that used in America being imported from Ireland. The qualities generally used weigh $3\frac{3}{4}$ to $4\frac{1}{4}$ oz. per square yard, and have a tensile strength at 65 per cent. humidity of 60 to 70 lb. per inch for the lighter weight and 100 lb. per inch for the heavier. The strength when coated is 10 to 15 per cent. more than uncoated in the case of high-quality linens, and 40 to 60 per cent. more with medium grade linen. Incidentally it is stated that a collodion made from the cellulose acetate, for which we are, we believe, indebted to Messrs. Cross and Bevan, is being used in Europe to make a transparent "celluloid" fabric which is used for wings instead of cloth. Sheets of this material, as tested by the reporters, weighed $9\frac{1}{2}$ oz. when $\frac{1}{100}$ in. thick, and had a tensile strength of 50 lb. per inch. Thicker sheets weighed 59 oz. per square foot and had a tensile strength of 325 lb. per inch. The latter are too heavy for wings, but might, it is suggested, be useful for flooring.

Some interesting results on the surface friction of fabrics observed in experiments at the Washington Navy Yard are included in this paper. The figures are not absolute, but the frictional resistance of each type of surface was compared with that of a sheet of plate glass. We quote the following results obtained at 70 miles per hour :—

Plate glass	1.000
Linen, No. 1 (high grade)	1.362
Linen, No. 1 (high grade), 1 coat varnish (No. 1,876)	1.162
Linen, No. 1 (high grade), 3 coats varnish (No. 1,876)	1.108
Linen, No. 1 (high grade), 3 coats varnish (No. 1,876), 1 coat spar varnish ...	1.061
Linen, No. 1 (high grade), 3 coats varnish (No. 1,877)	1.085
Linen, No. 1 (high grade), 3 coats varnish (No. 1,877), 1 coat spar varnish ...	1.081
Linen, No. 1 (high grade), 3 coats varnish (No. 1,877), 2 coats spar varnish ...	1.078
Balloon fabric, No. 3, cloth outside; double parallel	1.965
Balloon fabric, No. 3, cloth outside, double parallel, freshly singed ...	1.654
Balloon fabric, No. 3, cloth outside, double parallel, freshly singed and coated once with No. 1,876	1.345
Balloon fabric, No. 3, cloth outside, double parallel, freshly singed and coated three times with No. 1,876...	1.107
Balloon fabric, No. 3, cloth outside, double bias	1.902
Balloon fabric, No. 3, cloth outside, double bias, freshly singed	1.762
Balloon fabric, No. 6, cloth outside (specially woven), double bias ...	1.528
Balloon fabric, No. 6, cloth outside (specially woven), double bias, freshly singed	1.372
Aeroplane fabric, rubberised	1.079
" " aluminium coated ...	1.101

Assuming that the resistance varies with the speed in accordance with the formula $P = k V^n$, where P denotes the resistance in lb. per sq. ft., V the velocity in miles per hour and k a coefficient, then values of k and n are as follow :—

	k.	n.
Plate glass	1.78×10^{-5}	1.84
Linen, No. 1, varnish No. 1,876	1.56×10^{-5}	1.85
Linen, No. 1, uncoated ...	1.37×10^{-5}	1.92
Balloon fabric, No. 3 ...	1.92×10^{-5}	1.93

The concluding portion of the report consists of an elaborate report on the development and present status of aero-engines, and with this we hope to deal on a future occasion.

The Chadwick Lectures.—To-day and the two following Fridays, October 27, November 3 and November 10, Mr. William Stirling, M.D., D.Sc., of Victoria University, Manchester, will deliver lectures at 5.15 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C., on (1) "The Physiological Basis of Fatigue," (2) "Some Industrial Aspects of Fatigue," and (3) "Fatigue, a Universal Phenomenon of Life." Admission is free.

Board of Trade Department of Commercial Intelligence.—With a view to improving the organisation for assisting British trade by collecting and disseminating commercial information, the President of the Board of Trade has decided to amalgamate the Commercial Intelligence Branch and the Exhibitions Branch of the Board, and has appointed Sir William Clark, K.C.S.I., C.M.G., to be Comptroller-General of the combined Department, which will be known as the Department of Commercial Intelligence. Mr. Thomas Worthington, who has just retired from the post of Director of the Commercial Intelligence Branch under the age limit, has consented at the request of the President to assist the department in a consultative capacity as Commercial Adviser.

THE LATE SIR HENRY BENBOW, K.C.B.

In the death, at the age of 78 years, on the 20th inst., at his residence at Eastbourne, of Sir Henry Benbow, a prominent naval engineer officer of the past generation, there is recalled an episode in our naval history which shows that the courage and resource which has characterised the work of the *personnel* of the fleet in the present war is merely traditional, although none the less glorious. In the Nile Expedition of 1885, it was (to quote the Wolseley official despatch) "Chief Engineer Benbow's brilliant feat of repairing the boilers of the rescuing steamer under the heavy and continuous fire of the enemy which saved Sir Charles Wilson and his shipwrecked comrades." Although it is now 23 years since Sir Henry retired, and although there have since been stupendous changes, he never ceased to take a great and sympathetic interest in all that affected naval engineering.

Born on September 5, 1838, he entered the Navy as acting assistant engineer (2nd class) as long ago as 1861. In July of the following year he was appointed to H.M.S. Rattler, on the China station, returning to England early in 1866. In January following he joined H.M.S. Speedy (on the Home station), and when in this ship was promoted to engineer on January 30, 1868. His next appointment—in March, 1870—was to H.M.S. Volage, first on the Home station and later on particular service, and on this ship he remained $2\frac{1}{2}$ years. In January, 1873, he was appointed to the Portsmouth Torpedo School, and was promoted to chief engineer on April 3, 1879, and in the following December was appointed to the torpedo store at Malta. He was subsequently transferred on the station to Antelope (February, 1883), and later to H.M.S. Helican (April, 1883).

He was detailed for special service on the Nile in connection with the Nile expedition, and proceeded up the Nile under the command of Lord Charles Beresford. His name was brought to the notice of Lord Wolseley by Lord Charles Beresford for the splendid service he rendered, as we have already said, in repairing the boiler of the Sofia, the steamer which was proceeding to the relief of Sir C. Wilson, when exposed to heavy fire. "It took Mr. Benbow $10\frac{1}{2}$ hours to repair the boiler, as he had to do it nearly all with his own hands, the stokers and artificers of the vessel having been scalded when the boiler was shot through." He was specially promoted to the rank of inspector of machinery for the above-mentioned services (June 30, 1885), and Lord Wolseley, too, publicly presented Mr. Benbow with his own silver cigarette case as a mark of his personal appreciation of the gallantry and devotion shown by that officer in repairing the boiler of the Sofia.

In July, 1885, after his return to England, he was appointed for temporary service at the War Department, to supervise the building of steamers for the Nile expedition. His next appointment was to the Hong Kong dockyard, in November, 1886, and there he remained until June, 1889. He was promoted to chief inspector of machinery on December 31, 1888, and in October, 1889, was appointed for service in the Reserve at Devonport. He was placed on the retired list at his own request on September 8, 1893. In February, 1910, he was awarded the Good Service Pension. He was granted the Order of C.B. in recognition of the services referred to above, and in 1891 was given the D.S.O., and advanced to K.C.B. in 1902. He also received the Egyptian medal with the Nile clasp, and the Khedive's bronze star.

Personal.—In order to accommodate a Government Department, the Swedish General Electric, Limited, Canada House, Kingsway, London, W.C., are temporarily vacating their offices for the period of the war. On and after November 10 communications should be addressed to them at 5, Chancery-lane, London, E.C.—The Universal Concrete and Construction Company, Limited, have decided to restrict the business of the company and, in order to emphasise the fact, the name of the company has been altered to "The Ferro-Stone Glazing Company, Limited." Ferro-stone glazing bars of lengths up to 18 ft. can now be manufactured.—Mr. Michele N. Salvati, of 35, Via Maria Vittoria, Turin, Italy, has removed to 3, Via Montecuccoli.

The Institution of Civil Engineers: Awards for Papers.—In addition to the awards announced in April for papers read at the meetings, the Council of the Institution of Civil Engineers have made the following awards for papers published in the Proceedings without discussion during the session 1915–16 :—Telford Premiums to Messrs. Hubert Mawson (Liverpool), T. W. Keele (Sydney), R. W. Holmes (Wellington, N.Z.), W. Fairley (London), J. M. Greathead (Johannesburg), T. C. Hood (Manmad, India), and J. B. Ball (London); the Manby Premium to Mr. W. C. Cushing (Pittsburg, U.S.A.); and the Crampton Prize to Major C. E. P. Sankey, D.S.O., R.E. (London). The Indian Premium for 1916 has been awarded to Sir John Benton, K.C.I.E. (Eastbourne).

STARTING DIESEL ENGINES WITH LOW COMPRESSION.

To The Editor of Engineering.

Sir,—I am grateful to Professor Watkinson for his courteous consideration of the outstanding points raised in the first part of my letter. I am inclined to agree that a comparison of several of the 260 lb. per square inch compression curves shown in Fig. 3 with the type of curve shown in Fig. 5 (Engineering, September 22, 1916) does not prove that the lower limit of compression pressure to effect self-ignition has been approached, and I confess to some surprise at Fig. No. 1 in Professor Watkinson's reply. I cannot help thinking, however, that the "raggedness" of the peak in this, and in many diagrams in Fig. 3 referred to above, justify some doubt as to whether the pressures indicated can be accepted as veritable records of pressures attained in the cylinder. Moreover, there is a big difference between a compression pressure of 165 lb. per square inch and 30 lb. per square inch. I see Professor Watkinson sticks to his point, and I do not think the matter can be settled except by actual trial.

The really important point at issue, and one which I think is of great practical significance as regards the future of the internal combustion engine, is raised by the Professor in the latter portion of his reply. If the Professor is right, the rate of heat leakage from an intensely hot gas to the walls of the containing vessel is determined simply by the temperatures and by the area of cooling surface per unit volume, and is not appreciably affected by the density of the gas. Arguing on the basis of the kinetic theory of gases, Professor Watkinson says that if the mass of the gas be reduced to one half—its temperature remaining constant—the number of molecules which will collide per second with the walls of the enclosure will be reduced approximately to one-half. This I do not question. Nor do I disagree when he claims that the resulting increase in the mean free path of the molecules, due to decrease of density, will not greatly affect the result, though there should be an appreciable difference in this respect as between a compression pressure of 34 and one of two atmospheres.

Where I differ from Professor Watkinson is in his assumption that the above considerations determine the rate of heat leakage. Undoubtedly they influence the rate in conjunction with other factors, but the one dominating condition as regards the cooling effect of a surface on the contained gas is the temperature difference existing between the gas and the surface.

If the surface is as hot as the gas, no matter at what rate it is bombarded per second by the gaseous molecules, no cooling effect will be produced. If, now, in the case we are considering the molecules of a gas at a certain density and temperature collide with a cool surface a certain number of times per second, they will communicate heat to the surface at a rate determined by the difference in temperature between the surface and the gas, and the temperature of the surface will thereby be raised—*the said rise of temperature immediately resulting in a reduction in the rate of heat-flow from the gas to the surface.* It is sometimes assumed that in a gas engine such heat escapes almost immediately to the water jacket and is lost, but I think it is now generally admitted that during the period of combustion a very high temperature is confined to an extremely thin layer of metal in contact with the heated gas. In the paper by the late Lieutenant F. Trevor Wilkins, M.Sc., of the University of Birmingham, read by Professor Burstall at the Institution of Mechanical Engineers last Friday night, it was, I think, made clear that a certain amount of heat is returned from the surface to the gas during the expansion stroke; but I do not think it is generally realised that such high heating of the surface lamina acts to conserve the heat in the gas by limiting the rate of heat-flow from gas to metal. Now it appears to me that this has a very immediate bearing on the point at issue in this correspondence. If, as compared with standard conditions of working, the density of the charge be reduced to $\frac{1}{n}$ of its former density, the number of molecules colliding with the cooling surface in a minute portion of time will be approximately reduced to $\frac{1}{n}$ the former number and the heating effect upon the surface will be approximately $\frac{1}{n}$ the former effect. But what will happen in the next minute portion of time? Assuming that $\frac{1}{n}$ of the number of molecules strike the walls as was the case in the corresponding second period when working under standard conditions, these molecules will give up a much larger proportion of their heat at each collision than did the molecules in the former case.

From this it follows that the less dense charge must fall in temperature more rapidly than the denser one.

Professor Watkinson says the important matter in the above case is not the area of cooling surface per unit mass, but the area of cooling surface per unit volume, and that this latter ratio remained constant in his experiments. I would rather put it that the important matter is the aggregate heat exchange throughout the combustion period involved in the collisions of the gas molecules with a cooling surface under varying conditions of gaseous density—the volume and temperature of the gas and the surface conductivity and heat capacity of the enclosing vessel remaining constant.

May I suggest further that the assumption that the flow of heat from hot gas to surface in a Diesel engine is all a matter of molecular collisions with containing walls is not quite in accordance with known facts. I believe a large part of the exchange is due to radiation.

It is not at present, so far as I am aware, clear how far the intensity of thermal radiation from a hot gas is dependent upon the density of the gas. I believe it will be found that the total external radiation does not increase directly with the density, and that the cooler peripheral portions absorb a larger proportion of the total radiation from the mass when the gaseous mass is dense than when it is tenuous; but whether that is so or not, the radiation falling on the cylinder wall will raise its temperature, and under the conditions of varying density we are considering, the radiation from the denser gas will cause a greater surface rise of temperature, which in turn will again tend to limit the flow of heat from the gas to the cylinder wall. It may be objected that any rise in the temperature of the surface lamina in contact with the gas must increase the rate of heat-flow through the wall. This of course is so, but there appears no direct ratio in the matter. As mentioned above, the momentary development of intense heat seems to be confined to an extremely thin layer of metal, and the rate of heat-flow through the metal is so slow compared with the temperature changes in the working substance and the rate of heat exchange between the surface lamina and the working substance, that an increment or decrement of high gaseous temperature in the short combustion period of the cycle involves comparatively little change in the rate of heat-flow to the jacket.

Unless these points are admitted it seems to me no satisfactory explanation of the acknowledged thermal efficiency of high-compression engines is possible. As it is, one finds the accepted explanations sufficiently stimulating to thought. But once ascribe due weight to this thin lamina "give-and-take" effect, and it will be seen that on Professor Watkinson's assumption of cooling as due to molecular collisions a less dense charge must fall in temperature more rapidly than one of greater mass.

The more closely I study them the more important do the results Professor Watkinson has achieved appear to be, and if I still differ from him on some details referred to in this letter, I am none the less eager to acknowledge the brilliance of the idea he conceived and the skill with which he has worked it out.

I remain, Sir, yours faithfully,

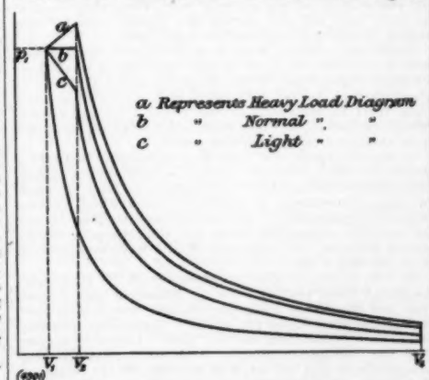
W. A. Benton.

Benton's Patents, Ltd., 5, Grosvenor Chambers, Broad-street, Birmingham, October 24, 1916.

To the Editor of Engineering.

Sir,—The points raised in your issue of October 13, in some comments upon Professor Watkinson's paper by Mr. W. A. Benton, regarding the thermal efficiency of the Diesel engine, are, as he says, much in need of clearing up. The prevalent text-book diagrams are about the only ones to be seen giving the pleasantly smooth and horizontal combustion line there depicted. In the writer's experience, diagrams so obtained are more in the nature of curiosities than of common occurrence in the practical working of Diesel engines.

Mr. Benton's second question regarding the relationship between the period of fuel injection and the period of actual combustion as shown on the indicator diagram



is one only to be answered by experimental evidence of a very exhaustive nature. The speed of the engine would appear to have an intimate bearing upon that relationship.

The other, and first, question put by Mr. Benton—whether the maximum pressure exceeds the compression pressure when the engine is working at its maximum thermal efficiency—may be answered in the affirmative by means of theoretical considerations alone. Thus, assuming that at a particular load the combustion line is a constant-pressure one, it is well known that the lighter or heavier the load becomes, this line becomes in general, not shorter or longer, as is assumed in theory, but takes up an obtuse or acute angle with the horizontal, as the case may be. At the lighter loads it often becomes difficult to tell from the cards where combustion ends and expansion begins, owing to the apparent amalgamation of the combustion and expansion lines. The reason for this, of course, lies in the general method adopted for governing the engine. The fuel supply is cut off at the pump when the load is diminished, but the fuel-valve opening remains unchanged. Hence the diminished fuel supply injected during a cycle at the lower loads is unable to maintain a constant-pressure line.

Assuming the combustion line to be straight, *i.e.*, that it has an equation of the form $p = mv + b$, and that combustion is completed at the same point of the piston stroke for all loads, the writer, some time ago deduced the following expression for the thermal efficiency:—

$$\eta = 1 - \frac{1}{r^{\gamma-1}} \times \left\{ \frac{2\left(x\rho^{\gamma-1} - 1\right)}{(\gamma+1)(x-1) + \left[\rho - x\left(\frac{\rho-1}{\rho}\right)\right](\gamma-1)(\rho-1)} \right\}$$

Where $\gamma = \frac{K_p}{K_v}$

r = compression ratio = $\frac{v_4}{v_1}$

ρ = cut-off ratio = $\frac{v_3}{v_1}$

and $x = \rho\frac{p_2}{p_1}$

the volumes and pressures being those as indicated in the accompanying figure, in which three diagrams are drawn showing:—

m with a positive value (*i.e.*, an acute angle).
$m = 0$ (a horizontal line).
m with a negative value (*i.e.*, an obtuse angle).

From expression (1) it can be seen that the efficiency increases with x for all values of ρ. The case $m = \infty$ is the case of constant volume combustion and evidently gives maximum efficiency.

Expression (1) therefore, in general, contradicts the usual theory that maximum thermal efficiency is obtained at the smaller loads, and shows that for maximum thermal efficiency the maximum combustion pressure must exceed the compression pressure.

Since x is the only variable in (1) (under the given assumptions), the measurement of m from the cards would give a convenient means of estimating relative thermal efficiencies at different loads.

Yours, &c.,

Wm. J. Walker.

"Ridgmont," Aircraft Esplanade, Farnborough, Hants, October 18, 1916.

ELECTRONS, QUANTA AND RELATIVITY THEORIES.

To The Editor of Engineering.

Sir,—It afforded me special pleasure to read the appreciative remarks by Mr. Fred. G. Edwards in your issue of the 20th inst. of the important work of the late Professor O. Reynolds, and I share also Mr. Edwards' opinion that Prof. Reynolds' fellow-men do not make sufficient of that work.

The mathematical treatment of the theory to which Mr. Edwards alludes appeared at the time (Cambridge University Press) under the title "The Sub-Mechanics of the Universe," vol. iii of "Papers on Mechanical and Physical Subjects"; but there exists also a more popularly kept exposition of the main points, excellently illustrated as well by interesting experiments, in the published reprint of the Rede Lecture, June 10, 1902, and this is titled "On an Inversion of Ideas as to the Structure of the Universe."

In the mathematical treatment of the theory undoubtedly only students of at least equally high attainments can satisfactorily follow Professor Reynolds, and this may in part answer Mr. Edwards' question at the end of his letter, and it certainly applies to me. I trust, Sir, for the sake of the great scientific interest attaching to the subject under discussion, you will kindly forbear if I mention that in your contemporary *The Engineer* there appeared in November, 1903, two excellent notices regarding Professor Reynolds' theory, explaining lucidly most of the points involved, while Professor J. D. Everett, F.R.S., had the kindness in July, 1904, to present me with a copy of his paper from the Proceedings of the Physical Society of London, vol. xix, also *Phil. Mag.*, July, 1904, bearing on the same subject and entitled "On Normal Piling." Further, during 1903 I had a most enjoyable interchange of letters with our late friend Mr. Thomas Thorp, F.R.A.S., who, like myself, was greatly impressed by what Professor Reynolds wished to convey and the fascinating points his theory raises and discusses as regards the constitution of the ether. Like to Mr. Edwards, to me also it has always appeared that Professor Reynolds presented us with "a truth," and physical science has made such progress since his time that it would be well worth to have his theory on "The Structure of the Universe" reviewed in the light of that progress by some of your physical contributors.

Very respectfully yours,

Albert Alfred Buss.

Barrowdale, 22, Egerton-road, Chorlton-cum-Hardy, Manchester, October 23, 1916.

Restriction of Imports: Insulating Materials.—The British Electrical and Allied Manufacturers' Association, King's House, Kingsway, London, W.C., announces that the Department of Import Restrictions (Board of Trade) has granted to the Association a special licence to import insulating materials in certain classes which are included in the list of prohibited imports. Electrical manufacturers, whether members of the Association or not, can avail themselves of this licence by making application to the Secretary of the Association. The Department of Import Restrictions desires it to be known that the granting of licence is a temporary measure to meet present urgent needs. This licence extends to January 16, 1917, at which time the necessities of the situation will be again reviewed. It is expected that firms in the meantime will make every effort to obtain in this country the supplies of insulating material which they require.

THE DEVELOPMENT OF APPLIANCES FOR HANDLING RAW MATERIALS AND MERCHANDISE AT PORTS AND OTHER LARGE CENTRES OF TRAFFIC.*

By Sir John Purser Griffith, M.A.I., M.Inst.C.E.

My colleagues on the Council have done me the signal honour of asking me to deliver the twenty-fourth "James Forrest Lecture," and have selected as the subject "The Development of Appliances for Handling Raw Materials and Merchandise at Ports and other large Centres of Traffic."

I have accepted the responsibility as an act of homage and affectionate regard for Mr. James Forrest, whom so many of the old members of the Institution regard with personal friendship, and who has said that "the chief happiness of his life has been to witness the prosperity and usefulness of the Institution.

As my life has been spent in close association with harbour and port engineering, I have been brought face to face with problems closely associated with the import and export trade of our country. If I, therefore, dwell specially on the handling of materials and merchandise in ports, and appear to overlook many of the similar problems associated with the internal trade and economy of our land, I trust charitable criticism will be extended to me.

The subject chosen by the Council is one of great and increasing importance; but it covers a world-wide field. It is obviously impossible to treat it in detail within the limits of a lecture. The numberless appliances and the various conditions to be dealt with would provide materials for many such lectures. I need only mention such books as "The Mechanical Handling and Storing of Material," by Mr. George Frederick Zimmer; "Cranes," by Anton Böttcher, translated by A. Tolhausen; and the classical work of Professor Adolf Ernst, of Stuttgart, entitled "Die Hebezeuge," to show the extent of the subject, and how much thought has been given, both at home and abroad, to the design and construction of such appliances.

All that I can do in the short time at my disposal is to bring under your notice the objects aimed at by the development of such appliances, and what I believe to be the economic advantages gained by their use. I also propose to touch on some striking examples, and finally to submit for your consideration a plea for their extended use on the ground of the benefit they are capable of conferring upon mankind.

The Object of Appliances for Handling Materials.

What, then, do we aim at by the introduction of appliances for handling raw materials and merchandise at our ports? I think it is a fair answer to say that it is to reduce the cost of raw materials and the finished article to the consumer.

Reduction in the cost of transport between the source of supply and the manufacturer or consumer is the primary object of such appliances. Quick loading and discharge of vessels is an important factor in freight charges. The ship represents capital invested, and has to earn sufficient in freights to cover interest on capital, sinking fund, or depreciation, working and maintenance expenses, including port charges.

For each particular ship this can be represented by a daily charge, and is so represented in chartering a ship by the charge per day for demurrage, to cover delays in port by the merchant or consignee, beyond the period allowed in the charter for the discharge of the vessel. It is obvious that the port which gives vessels the most rapid dispatch will become especially popular with the shipowner, and favourably influence freights to that particular port.

The late Sir William White, at the Engineering Conference in 1907, made the following striking remarks:—

"As a looker-on it has been obvious to me for many years that greater rapidity in dealing with cargoes must be the essence of success in commercial operations.

"It was also shown by Dr. Inglis many years ago (on the basis of information supplied by shipowners) that one controlling condition in the profitable running of cargo steamers is the time they remain in port for the purpose of shipping or discharging cargoes, during which time freight earning must be interrupted."

The Influence of Rapid Discharge on Port Charges.

The rapid clearance of ships in our ports is a matter of vital importance from the port point of view. The quay walls of a port are in general the most costly item of port equipment. The earning power of the port may, with advantage, be referred to the income derived per lineal foot of quay, and the cost of the port may be referred to the same unit.

The cost of the port per lineal foot of quay will include the capital expenditure on the quay walls, docks, roads, tramways, sheds, power and lighting appliances, and the outstanding capital cost for the dredging, lighting and buoying of the harbour. These represent a capital sum on which there is an annual charge for interest and sinking fund. To this must be added the annual expenditure on the maintenance and working expenses of the port, together with establishment charges. If the aggregate sum representing these annual charges is divided by the length in feet of the quay berths, we arrive at the annual expenditure on the port per lineal foot of berthage. In a similar way, if we find out what the annual income of the port amounts to from dues on shipping and goods, rents, and other charges, and divide this sum total by the length of quay berthage in feet, we arrive at the earning power of the port per lineal foot of berthage. We are now in a position to say whether the port as a whole is solvent, or whether the port charges are sufficient or excessive. We arrive, in fact, at what the average earning power of each foot of quay should be.

In a detailed examination of different portions of the berthage on these lines it will be found that some quays pay much better than others; that in fact some quays are much more efficiently worked than other portions. It will generally be found that berths appropriated to fixed and regular trades yield a higher return than the open berths devoted to the general trade of the port. This naturally follows, because berthage is not appropriated to a particular trade unless that trade is regular and of sufficient volume to warrant an appropriation. This all points to the necessity of insisting on rapid discharge and clearance of ships at these open quays. From the annual expenditure per lineal foot and the income per lineal foot of quay we can at once put our finger on the weak spot and say that such and such a quay must be worked at greater pressure. The importance of appliances for handling raw materials and merchandise immediately becomes evident. It is only by such appliances that you can ensure the rapid discharge of the ship, make your port financially sound, keep down port charges, and thus make your port attractive to both shipowners and traders.

Ship's own Appliances for Handling Cargoes.

It is impossible when dealing with the subject of this lecture to omit all reference to such appliances as are fitted on vessels in certain trades for handling cargoes both for loading and discharging with the ship's own gear. From very early days the winch worked by hand was in use on sailing vessels for raising cargoes from the holds. With the advent of steamers the hand winch was replaced by the steam winch, worked from the ship's main boilers, or from an auxiliary boiler. This arrangement is still in general use. Steamers in the oversea trade frequently call at ports where there are no shipping quays, and the cargoes are loaded from or discharged into lighters or other vessels over the side. To meet this, and also to accelerate the speed of loading or discharging, derricks have been attached to the ship's masts, and even special derrick posts have been fitted. By this means derricks worked by steam winches command the vessel's hatchways, and also lighters or vessels alongside. Cases exist of vessels in which the ordinary masts have been dispensed with, and only derrick posts fitted; and instances have been quoted in which a vessel so fitted, carrying over 10,000 tons of ore, has been discharged at the rate of 300 tons per hour.

Where a vessel is engaged in a regular trade between fixed ports to which regular berthage is appropriated, elaborate appliances on the ship for discharging and handling cargo are unnecessary. It is more economical in such cases to have the appliances ashore, where they can be kept constantly at work. Cargo-handling plant on the ship is, of course, only used when the vessel is in port, and lies idle during the voyage, and for this reason is not as economical as shore plant.

There are, however, some large ports, such as Hamburg and Rotterdam, on great inland waterways, serving an immense hinterland, where ships discharge portions of their cargoes on to the quays, and portions into the huge river barges found on the rivers Elbe and Rhine. Steamers trading to these ports are, therefore, equipped with their own cargo-handling plant.

It would appear that this ship equipment has had a deterrent effect on the proper equipment of ports. Shipowners having their own appliances have declined to make concessions in freight to ports which possess their own equipment. Merchants have declined to pay for harbour equipment when the shipowners' contract covers hoisting the cargo out of the hold and placing it on the ship's rail.

So well equipped were the steamers of the Hamburg-American Line, trading between Hamburg and Boston, that the steamship company advised the Boston port authorities that it did not desire a permanent handling equipment established in the port. It would appear that the German company, with its up-to-date ship equipment, hoped to be able to capture the trade of Boston by embarrassing its competitors, who might depend more upon port equipment supplied by the local authorities.

Our portal authorities have been slow in realising the importance of rapid despatch in loading and clearing ships frequenting their ports. They have frequently checked the extension of port equipment by excessive charges, forgetting that it is not so much making a profit out of such appliances which should be sought as making the port as a whole more efficient and economical.

Shore equipment is essential for the handling of materials on shore, and for hastening the clearing of wharves and sheds. This is as essential as the discharging of the vessel, for if the landed cargoes are not removed rapidly, the discharge of vessels is delayed for want of quay space upon which to land the cargoes. The congestion of our ports from which the nation has suffered during the present war has been largely due to imperfect facilities for handling the goods when landed.

My attention was drawn to the importance of port equipment for handling cargoes more than 40 years ago in a curious way. The late Herr Dalmann, the chief engineer of the port of Hamburg, visited Dublin in the early seventies to see the operations of building, lifting and laying the great masonry blocks of 360 tons which the late Dr. Bindon Blood Stoney used in the extension of the quays of Dublin Harbour. Herr Dalmann at the close of his visit invited me to Hamburg, and amongst other attractions mentioned that a greater tonnage of shipping was accommodated in Hamburg per lineal foot of quay than in any English port. My curiosity was excited, and I determined to see how this was accomplished. Its importance was brought home to me, as I knew that at the time the costly deep-water berths in Dublin were the least remunerative quays in the port. The result of my visit was to show me that the equipment of the Hamburg quays with cranes had been carried out to an extent quite unknown in England and our British ports, and arrangements as regards charges for their use were adopted which made it advantageous for the trader to use them. The result was that vessels were discharged and loaded rapidly, and the costly quays worked efficiently.

As regards the development in the handling of raw materials and merchandise, my experience in the Port of Dublin, extending over a period of nearly 50 years, covers the period of change from purely manual labour in the discharge and loading of vessels to the use of machinery and mechanical appliances on a very considerable scale.

I now propose to give some instances of appliances for handling coal, ore, grain, oil, timber heavy machinery, such as engines and boilers, general merchandise and packed goods. These have been selected, not with the intention of suggesting that they are suitable for general application, but as striking examples of special appliances for particular purposes, which may prove an incentive to the extension of mechanical appliances for handling raw materials and merchandise in our ports and centres of traffic.

Coal Handling.

In the year 1869, when I first became connected with the Engineering Department of the Port of Dublin, all coal entering the port was carried in sailing vessels, of which the Whitehaven brig was the typical example. With a favourable wind these vessels entered and left the port in fleets, with the result that the coal supply of the city fluctuated within wide limits, and prices varied accordingly. These vessels were practically the coal stores of the city, lying in the port for weeks. The coal was raised from the ship's hold in wooden tubs by a hand winch worked by a couple of the crew. The coal was filled into sacks, and weighed on a scale fixed on the ship's deck. It was then carried ashore on men's backs to carts for distribution to the customers. The price of coal was exhibited on a board at the ship's gangway. Even for the gas supply of the city coal was handled in the same way, and large storage had to be provided at the gasworks to meet the uncertain supply due to weather conditions. Many serious fires occurred in these large coal stores due to heating of the coal.

What a change has come over the scene! The sailing collier has disappeared and been replaced by steam colliers, which arrive in port in the morning and leave the next evening. These vessels sail with clock-like regularity, and are designed to carry the maximum of coal in vessels of suitable size and draft for the particular coal port with which they trade, and they are engined for speeds necessary to meet the tidal conditions of these ports. The modern collier is designed with large hatchways to facilitate the loading and discharging of coal, and to reduce trimming.

Coal-Loading Appliances.

In the matter of loading coal into ships at the coal ports there has perhaps been less change in principle than in the discharge of cargoes. We find the coal-staith in use in the River Tyne at a very early date. The object was to bring the loaded colliery wagons into such a position that the coal could be discharged by gravity and carried direct into the holds of vessels. The modern staith is merely a development of this idea, and is so designed as to allow trains of coal wagons to discharge in quick succession. In some cases the wagons are run up on high staging commanding the coal shoots; in other cases the wagons loaded with coal are raised vertically to the necessary height for tipping, while in some recent instances the coal wagons discharge into a coal hopper below the ground level from whence the coal is delivered by elevators into the ships' hatches.

The only examples of American coal-loading appliances which I propose referring to are the coal hoists at Toledo, Ohio, constructed by the Brown Hoisting Machinery Company of Cleveland, Ohio. These hoists are designed to raise and dump cars containing 100 tons of coal, and records show that each machine will handle from forty to fifty cars per hour. The car is pushed into the cradle by the "Ground Hog." It is clamped on the cradle, and as the cradle is hoisted the wagon is turned over through an angle of 160 deg. and emptied.

Trimming of coal in the holds of the primitive colliers was a costly operation; but this has been reduced to a minimum in the modern steam collier, with its large hatchways and capacious and unobstructed holds. This not only facilitates loading, but also discharge, permitting of the discharge by mechanical means.

Coal-Discharging Appliances.

The discharging of coal from the ship is still, it may be said, in a transition state. Although the methods described of discharging the old sailing collier in Dublin are out of date, yet a considerable quantity of coal is excavated in the holds by manual labour, and the buckets or skips are filled by the same men. The bucket carrying from 20 to 30 cwt. of coal is then hoisted either by the ship's own tackle or by cranes on the quays.

Considerable advances have been made in the use of

* The "James Forrest" Lecture, delivered before the Institution of Civil Engineers on October 24.

grabs or excavators to dig the coal out of the ships' holds, and reduce manual labour to a minimum.

COAL HANDLING AND WATER CARRIAGE OF COAL ON THE AIRE AND CALDER NAVIGATION.

One of the most striking systems of the handling of coal from the colliery to the coast for shipment is that devised and carried out by Mr. William Hamond Bartholomew, M.Inst.C.E., on the Aire and Calder Navigation. It is probably the most successful case of inland navigation in England at the present time. This navigation forms an important section of the waterways connecting the ports on the Mersey with those on the Ouse and Humber on the east coast, and passes the coal-fields of West Yorkshire, and is connected by water with the coalfield of South Yorkshire.

The port of Goole on the River Ouse is the eastern terminus of this navigation, the waterway of which has been greatly improved and adapted to mechanical haulage. The principal locks have been enlarged to 460 ft. in length, 22 ft. in width, and with 9 ft. of water over the gate sills, while the waterway has a minimum sectional area of 457 sq. ft.

The improvement of the waterway has allowed of the compartment boat system, which has been designed by Mr. Bartholomew especially for the carriage and shipment of coal and other minerals. Each compartment forms a rectangular boat, and carries 40 tons of coal. The compartments are coupled together and formed into a train consisting of a tug and 20 or 30 compartments and carrying from 800 to 1,200 tons of coal. Each train is worked by four men.

The several compartments are loaded at the colliery staiths, and on arrival at Goole are floated into the cradles of powerful hydraulic hoists, in which they are secured, raised to the required height, and tipped over, discharging their contents into shoots and thence into the ship at the rate of from 200 to 300 tons per hour, according to the suita bility of the ship to receive such cargo.

The system has the further advantage of enabling the compartments to be taken out of the water on railway trucks specially designed for the purpose, and transported upon them over the colliery railways to be loaded at the pit-head, and returned loaded by the same means to the waterway. In the case of one colliery about 1¼ mile from the waterway, compartments are transported over gradients of 1 in 27.

Comparing the compartment system of conveyance with that of ordinary barges, it would need eight or twelve of the latter of 100 tons each to convey the equivalent of the compartment trains under consideration, and would require 16 or 24 men to work the barges, and eight to twelve horses to haul them, whilst the time required for transhipment from ordinary barges and the cost involved make such an operation practically prohibitive. It is worthy of note that this navigation is in close touch and competition with the North-Eastern Railway, the Lancashire and Yorkshire Railway, the Hull and Barnsley Railway, the Great Central Railway, and the Great Northern Railway.

COAL-HANDLING APPLIANCES ON THE RIVER THAMES.

The enormous importation of coal into the Thames for domestic and manufacturing purposes has naturally resulted in some of the best installations in this country for the discharge of coal being found in the Port of London. Although there is some admirable equipment belonging to the several gas companies, yet I propose confining my reference to the plant used by Messrs. William Cory and Son, Limited. I am especially indebted to their engineer, Mr. H. Shoosmith, M.Inst.C.E., for information and facilities to inspect the company's plant. This plant represents the experience gained from a very large coal trade, extending over a period of 50 years.

In 1858 Messrs. Cory took the first step in the mechanical discharge of coal. They purchased a hulk, or barge, which had been built for wreck lifting, and was of considerable beam. On this they erected six hydraulic cranes, made by Messrs. Armstrong, three on each side of the barge. The barge was fitted with a gas works, hydraulic plant, and capstans, and was so successful that a few years later the firm constructed a duplicate plant. The two barges were called "Atlas, No. 1" and "Atlas, No. 2." For some 20 years they were the recognised stations for discharging steam colliers on the Thames; and the standard specification for a steam collier to trade to the Thames was that the hatches should be made to fit Cory's derricks.

As colliers increased in size, four additional cranes were fitted on these barges, one on each corner, with long jibs, which derricked or luffed, so as to vary the radius. These barges were in use up to the year 1900. The next development was the introduction of coal grabs, in consequence of labour troubles.

In 1889 Messrs. Cory built a derrick pontoon, 550 ft. in length. This allowed two ordinary sized colliers to discharge on one side of the pontoon. The pontoon was fitted with luffing cranes and grabs which discharged the coal from the steamers into hoppers on the pontoon. From the hoppers the coal descended into an automatic weighing machine, which discharged the coal into a reservoir or bin, from which it was discharged into river barges on the opposite side of the pontoon from the ship. This pontoon, known as "Atlas, No. 3," discharged on an average 1,250,000 tons of coal per annum, and was continuously at work on the Thames until 1915, when it was requisitioned for use in the port of Rouen. When being towed across the Channel, it encountered a very heavy storm and foundered off Dungeness.

On account of the obstruction in the river, the London Port Authority would not allow another coal pontoon to be moored in the river channel. Subsequent additions to the coal-handling plant of Messrs. Cory were made ashore.

About the year 1900 Messrs. Cory reconstructed one of their Erith wharves, and erected on it five electric luffing cranes fitted with Hone grabs. A few years later the Erith pier was rebuilt and furnished with five transporters, to work double-chain grabs. The transporters were designed so that the grabs could be raised or lowered, opened or closed, while the grabs were in transit. These transporters are used for unloading coal from the ship, either into railway trucks on the pier, or into barges alongside. The transporters are fitted with automatic weighing machines, which have been brought to great perfection, being accurate and reliable. The disadvantage of this form of transporter is that the grab cannot be rapidly lowered into any part of the hatchway, and in their more recent installations Messrs. Cory have reverted to the luffing crane. These cranes, coupled with similar weighing machines to those in use at Erith on the transporters, have worked most satisfactorily.

The size of the steam collier has steadily increased, and in rebuilding the coaling jetty at Galleons, Albert Dock, it was decided to be prepared for vessels up to 8,000 tons. The cranes for this depot have been made with a maximum radius of 83 ft. so as to clear such a vessel and load into barges overside. The cranes are fitted with double-chain grabs, and are provided with automatic weighing machines.

At Dagenham Dock Messrs. Samuel Williams and Sons have an admirable coal-discharging plant of the straight-line transporter type, but smaller than those in use at Erith. The cantilever extending over the ship can be run in at will and housed, so that there is no difficulty in bringing a vessel alongside.

ORE AND MINERAL HANDLING MACHINERY.

The success of the steel industry in the United States of America is principally due to the scientific treatment and economical handling of the iron ore and the coal. The problem of bringing together the coal and iron ore is often one of great magnitude. Distances of over 1,000 miles separate the iron mines around Lake Superior and the coal deposits of Pennsylvania. Yet this transport has been so successfully and economically done that the great steel works of Pittsburg have developed as a consequence.

Some of the most striking developments of appliances for handling minerals and ore have been associated with this great industry. From the mines the ore is brought by rail to the lake port, where special docks have been constructed at which the lake steamers are loaded. At these docks huge bins have been built, over which the trains of wagons run and drop their loads.

From these bins the ore can be discharged by shoots into every hatch simultaneously. The great charm of this arrangement is that the bin storage ensures continuous loading, and vessels are not delayed awaiting the delivery of the ore by the wagons.

ORE TRANSPORT STEAMERS ON THE AMERICAN LAKES.

Specially designed steamers are features of this trade. The following description of one of the more recent steamers will serve to describe the class as a whole, although dimensions vary. The vessel I have in mind is 560 ft. in length over all, 56 ft. beam and 32 ft. in depth. The cargo hold is free from stanchions and cross-bracing or bulkheads. The sides and ends of the hold slope in the form of a hopper. The hold in the instance referred to is 409 ft. long, 43 ft. wide at the top and 24 ft. wide at the bottom. Arched transoms span the hold about 12 ft. apart. These transoms support the upper works and hatch covers. The vessel carries 11,000 tons of ore, and is fitted with water-ballast tanks in the double bottom and sides.

The docks are of such a form and size that several vessels can be loaded at the same time. At Duluth in one dock 64,000 tons of ore have been loaded into 14 vessels in 24 hours, or an average load per vessel of 4,571 tons. The unloading of vessels is what limits the speed, and a study of the various methods adopted is of great interest. I should like to refer briefly to the Hulett system, which, as far as I have been able to discover, is one of the most effective methods in use on the great lakes.

The Hulett unloaders are designed to work either by steam or electricity. The machines consist of a movable crane or gantry, travelling along tracks parallel to the waterway, and spanning any desired number of railway tracks. This gantry carries two girders at right angles to the face of the dock. Along these girders a trolley or carriage, carrying a walking trame, travels backwards and forwards. At the outer end of this beam there is a vertical leg, at the lower end of which is the scoop, or grab, having a capacity of from 3 to 17 tons. This leg is hung on trunnions and can be rotated in either direction. By means of hoisting mechanism the walking beam is made to oscillate up and down, carrying the leg and grab down into the vessel's hold and up again on to the quay. These machines are primarily designed for handling ore from the ship to the railroad car direct, but when it is necessary to store the ore for a length of time in stock piles, the crane or gantry is provided with a cantilever extension, running back at a sufficient elevation to clear the piles of ore.

In working the unloader, the trolley or carriage runs out on the girders, the outer or water end of the walking beam is brought down till the bucket-carrying leg enters the hatch, and the grab rests on the ore in the hold. The grab is then closed, the leg raised, and the trolley brought back into a position from which the ore can be dumped through a shoot into the railway cars beneath, or, after running up the cantilever extension, on to the stock pile.

The operator controlling all the motions of the machine, except moving along the dock, stands in the leg immediately over the grab, going down through the hatch with it, and watching the operations of the grab very closely. By means of the rotating trunnion the operator is able to make the grab reach all the ore in the vessel The wide-open spread of these grabs is from 18 to 20 ft. These machines have removed, without trimming, 95 per cent. of the cargo of a modern vessel, with a minimum rate of unloading of 200 tons per hour and a maximum of 680 tons.

The Brown Hoisting Machinery Company, of Cleveland, Ohio, have constructed some excellent coal and ore handling plant, and have been kind enough to obtain for me some photographs of the most striking examples. Amongst these is the coal-handling installation of the Pittsburg Coal Dock Company, at Duluth, Minn. It is said to be the largest in the world, capable of taking coal from the steamers to a 1,000,000 tons storage yard at the rate of 1,500 tons per hour.

A special automatic screening apparatus is provided for separating the coal into the various marketable grades.

Another interesting plant is at work at Fairport, Ohio, and consists of six fast unloading electric trolley grabs, delivering ore from the ship either to rail or store. Five-ton grabs are used, and 10,000 tons of ore have been discharged in nine hours.

GRAIN-HANDLING APPLIANCES.

England lagged behind in the adoption of grain-handling appliances, and we are still familiar with old methods of filling the grain into sacks in the holds of vessels, hoisting the sacks on deck by hand or steam winches for weighing and adjustment, transferring the sacks on men's backs to carts or railway wagons, whence they are transferred to the granaries.

The granary in these islands, until a comparatively recent date, consisted of a warehouse with floors on which the grain was stored to variable depths by manual labour.

The first advance was the introduction of elevators for raising the grain to the several floors, and belts and shoots to distribute the grain over the floors. Gangs of labourers were, however, still employed for turning it over for cooling.

In America, at a very early date, the handling of grain became a pressing problem. The economical transit of grain from the freshly broken-up prairies of the West to the European market was a matter of vital importance to the Western States. Dearth of labour gave the impetus to the invention and introduction of mechanical appliances, and the erection of silos, or binstores, was one of the earliest and most important steps. The combination of elevators and silos solved the problem of storage. The force of gravity was utilised in every possible way. The mechanical elevator raised the grain in the most economical manner to any required height, from whence it could be distributed by gravity from the store to the wagons, ships, or barges. Even after great progress had been made in the loading ports of the United States, the handling of grain at the discharging ports of Europe, and specially at those of the British Isles, was antiquated and costly.

Considerable progress has, however, been made of recent years in the discharge and handling of grain in our European ports by the introduction of fixed or portable elevators on land, or by floating elevators in the docks and harbours. The elevator leg with its chain of buckets is lowered into the hold of the vessel where grain is carried in bulk. These elevators are worked by steam or electricity, and discharge the grain ashore, or into barges or vessels lying alongside.

The pneumatic discharge of grain, which was introduced by Mr. Duckham, of the Millwall Docks, about the year 1890, has of recent years made considerable progress, especially abroad. Suction pipes are lowered into the ships' holds, and the grain extracted and delivered into adjoining stores, or overside into barges or ships. Although a British invention, it has been chiefly developed in the principal Continental ports. A large number of floating pneumatic elevators, constructed by Messrs. Luther, of Brunswick, were, before the war, at work in the Port of Rotterdam, where immense quantities of imported grain were transhipped from ocean-going vessels to the great river barges which navigate the Rhine.

Pneumatic elevators are specially useful for the discharge of grain carried in parcels in the various holds of the modern ocean trader. It would be impossible to pass the ordinary bucket elevator into many of these holds, but the pneumatic suction pipe can be led through the smallest hatchway, passed round angles, and the inlet nozzle led into the most remote corners of the holds, dispensing entirely with manual labour otherwise necessary to trim the grain to the elevator.

Pneumatic discharge requires greater engine power than the ordinary bucket elevator, and it is, therefore, often best to combine the two systems, using the pneumatic apparatus to discharge the ship, and the bucket elevator and distributing belts to handle the grain ashore. There can be no doubt but that the pneumatic discharge is advantageous to the grain, for it separates the dust from the grain, and removes a fruitful source of heating. And yet, curiously enough, this separation of the dust from the grain has actually proved a deterrent to the use of pneumatic plant, the reason being that the removal of the dust meant a material loss of weight, although the quality of the grain was improved. In many instances arrangements have been made to return the dust to the grain before it is passed to the weighing machines.

(To be continued.)

DIESEL ENGINE TRIALS.

*Trials on a Diesel Engine, and Application of Energy-Diagram to obtain Heat Balance.**

By the late Lieut. F. Trevor Wilkins (Northumberland Fusiliers), M.Sc., of the University of Birmingham, Graduate.

Introduction.—The following paper contains a description of some trials carried out on a small Diesel engine in the power station at the University of Birmingham. The manner of conducting these trials and of working out the results enables the author to present additional figures to those usually given in descriptions of similar investigations. The indicator diagrams obtained in the present trials were redrawn upon a heat-energy chart, and by this means any differences between the theoretical and practical cycles are clearly exhibited. Among the chief points of interest derived from this method of procedure were the following :—

(1) The amounts of heat passing to the cylinder walls and to the exhaust were accurately determined. The heat-flow during the compression and expansion strokes was separately estimated; also in each case the period during which this heat-flow takes place was definitely indicated.

(2) Curves can be shown giving the temperature in the engine cylinder at any point during compression and expansion, and an accurate heat balance-sheet drawn up.

Summary of Method.—All charge quantities entering the engine cylinder were accurately measured; on the other side of the balance-sheet precautions were taken to obtain an accurate indicator diagram. From these sources the volumes and pressures of cylinder charges of known weight and composition were estimated, enabling the indicator diagram to be transferred to Professor Burstall's Energy-Diagram for Gases.† On this diagram the internal energy and temperature at any point in the cycle may be read off directly, thus making it possible to obtain a fairly approximate idea of the magnitude of the heat-flow through the cylinder walls, and also of the periods in the cycle in which it takes place.

Description of the Apparatus used in the Trials.

Engine.—The engine was built by the Maschinenfabrik Augsburg and laid down in 1906. Since that date it has entirely been used for experimental purposes, probably running an average of only 100 hours per year. It is rated as developing 8 b.h.p. at 280 r.p.m., and is of the standard four-cycle, heavy cast-iron A frame vertical single-cylinder construction. The cylinder dimensions as measured before the trials were 10.61 in. stroke and 6.50 in. bore.

Indicator.—The diagram optical indicator, Fig. 1, below, expressly designed and constructed for these trials, is shown in section and plan in the general arrangement. The novel feature in the design is the means adopted for keeping the diaphragms at as uniform a temperature as possible. For this purpose Professor Burstall suggested the use of two diaphragms. These were connected at their centres by a stop, and through the space between the diaphragms steam was blown both when running engine tests and in calibrating the scale of the diaphragms (Fig. 2, above).

The indicator was calibrated immediately before and after each trial. A Crosby dead-weight gauge-tester was employed, care being taken to move the weights gently and to avoid all shock when altering the load. Two calibration diagrams were taken before and after each test, and the final scale adopted was the mean of those furnished by the four cards obtained. After scaling up the diagram and averaging the ordinates, the pressures were read off the calibration curve, and a mean indicator diagram drawn to a large scale. This diagram was then carefully planimetered. When taking cards a rather long exposure was used, varying from 15 seconds in the half-load trial to 30 seconds at full load, Fig. 11, page 424. The trace obtained on development gave, therefore, a mean card of from 35 to 70 working cycles. These long exposures rendered it possible for the number of cards taken during a test to be reduced to four only, but these were sufficient to represent from 140 to 280 cycles. For purposes of comparison the approximate area of each diagram was ascertained by finding mean heights, &c., and the greatest percentage differences obtained between the individual diagrams of a test were 1½ per cent. in the case of the full-load diagrams, 2 per cent. at three-quarter load, and 3 per cent. at half-load.

Measurement of Injection Air.—In the engine as originally constructed the first stage injection air-compression was carried out in the engine cylinder, an overflow valve in the cylinder head tapping off a small quantity of air at each compression stroke. The air then passed through an intercooler to a high-pressure compressor cylinder, in which the pressure is finally raised from 160 lb. per square inch to the pressure of the bottles. For the trials this overflow system was cut out, air being supplied to the compressor cylinder from a storage reservoir of known capacity, and pumped up to nearly the same pressure before each trial.

Measurement of Main Air Charge.—The air supply was measured by a Parkinson wet meter of 1,200 cub. ft. per hour capacity, or 10 cub. ft. per revolution. This meter was connected to the inlet pipe of the engine by an 8-ft. length of 2-in. internal diameter iron pipe; at the meter end of this was placed a cylindrical iron tank 4 ft. 6 in. by 2 ft. 6 in. in diameter. A throttling plate fitted between the tank and meter was adjusted until the pressure difference across the meter as shown by the water-gauge was practically steady. This arrangement quite effectively damped out the intermittent demand for air, the meter reading very steadily with a pressure difference across it of between $\frac{1}{8}$ and $\frac{1}{16}$ in.

The meter was set in the standardising position, and during the trials the water-level was maintained by means of a water drip. Light spring cards were taken off the engine before and after adding the meter, and no appreciable difference was noted. No air can pass through this type of meter without its measurement being recorded, unless the pressure difference is sufficiently great to depress the water-level 1½ in. and to by-pass under the partitions of the air compartments. The occurrence of this is indicated by the noise produced.

Fuel.—The fuel used throughout these tests was supplied from one barrel of standard Royal Daylight paraffin. The oil was contained in a tank placed on the platform of a weighing machine, the scale of which was graduated to half ounces. To this tank a fine adjustment needle-valve was fitted, through which the oil dripped into a small brass vessel fitted with a gauge-glass. The quantity of fuel was measured by opening the valve sufficiently to keep the oil-level in the gauge-glass constant, and timing the drop of the weighing-machine lever at different increments of loading.

Cooling Water.—The jacket water was supplied from one or other of two calibrated gravity tanks. The temperatures at inlet and outlet were taken in thermometer pockets 6 in. from the inlet at the bottom of the water-jacket, and 3 in. from the outlet by the exhaust valve.

Revolutions.—These were taken from a counter driven off the cam shaft.

Table I.—*Test Results.*

Units	Half Load.	Three-quarters Load.	Full Load.
Date of trial	15.6.13	17.6.13	25.6.13
Duration .. .. .. Min.	60	60	60
Barometer .. .. mm.	753	748.5	755
Air temp. .. .. .. Deg.C.	21.7	21.4	24.5
Revs. per min.	277.17	275.07	271.97
Mean ind. press. .. Lb. per sq. in.	55.27	70.35	86.14
Cooling water .. Lb. per hr.	139	157	225.5
Inlet temp. .. .. Deg. F.	75.4	75	81
Outlet temp. .. .. Deg. F.	165.6	167.9	163.85
Blast pressure .. Lb. per sq. in.	604	604	604
Injection air .. Lb. per hr.	6.86	6.5	5.13
Main air charge .. Cu. ft. per hr.	1555	1538	1526
,, ,, .. Lb. per hr.	115.42	113.72	112.275
Fuel .. .. Lb. per hr.	2.094	2.688	3.389
Mean jacket temp. .. Deg. F.	120.5	121.4	122.4

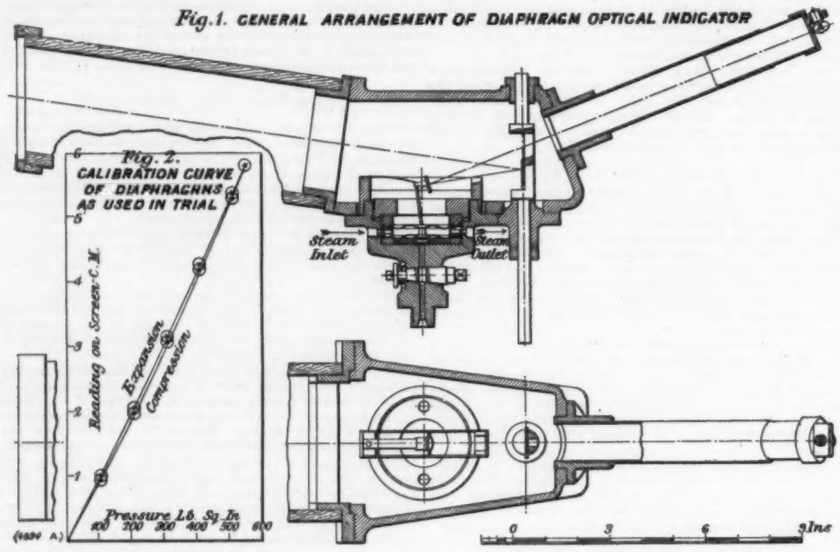


Fig. 1. General Arrangement of Diaphragm Optical Indicator

Fig. 2. Calibration Curve of Diaphragms as used in Trial

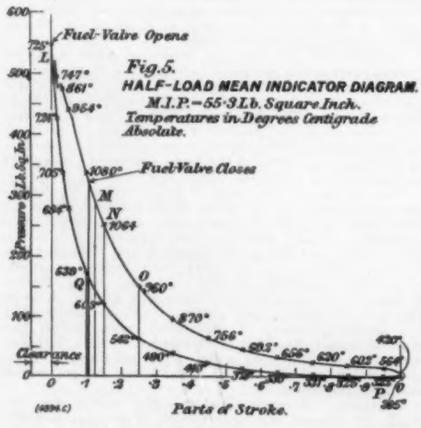


Fig. 5. Half-Load Mean Indicator Diagram. M.I.P.=55·3 Lb. Square Inch. Temperatures in Degrees Centigrade Absolute.

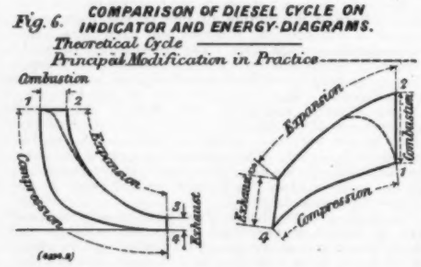


Fig. 6. Comparison of Diesel Cycle on Indicator and Energy-Diagrams. Theoretical Cycle ——— Principal Modification in Practice ----------

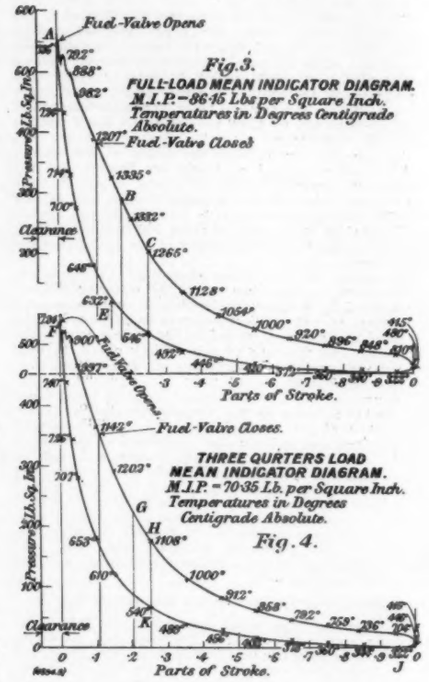


Fig. 3. Full-Load Mean Indicator Diagram. M.I.P.=86·45 Lbs per Square Inch. Temperatures in Degrees Centigrade Absolute.

Three Quarters Load Mean Indicator Diagram. M.I.P. = 70·35 Lb. per Square Inch. Temperatures in Degrees Centigrade Absolute.

Fig. 4.

* Paper read before the Institution of Mechanical Engineers, Friday, October 20, 1916.

† Proceedings, I.Mech.E., 1911, page 171.

Load.—The load was applied by a rope brake, the ropes passing half round the flywheel and attached at the ends to two spring balances.

General.—All the instruments used in the trials were calibrated, and in working out the results the corrections are taken into account. The engine was started up from 2 to 2½ hours prior to the commencement of the test, and for an hour before the start was running under test conditions. The test records were taken by one person only, and readings were taken in prearranged order at definite intervals.

Adjustment made during the Trials.—(1) The valve on the cooling water inlet pipe was gradually opened in order to keep the temperatures at inlet and outlet constant. This was necessary, since the reduction in head as the surface of the water sank in the gravity supply tanks lessened the amount of water passing in a given time. This adjustment was not needed for the half-load trial and only slightly for the three-quarter load trial.

(2) The valve on the second stage injection air-compressor cylinder outlet was adjusted to keep the blast pressure constant, as the compressor output varied with the lubrication.

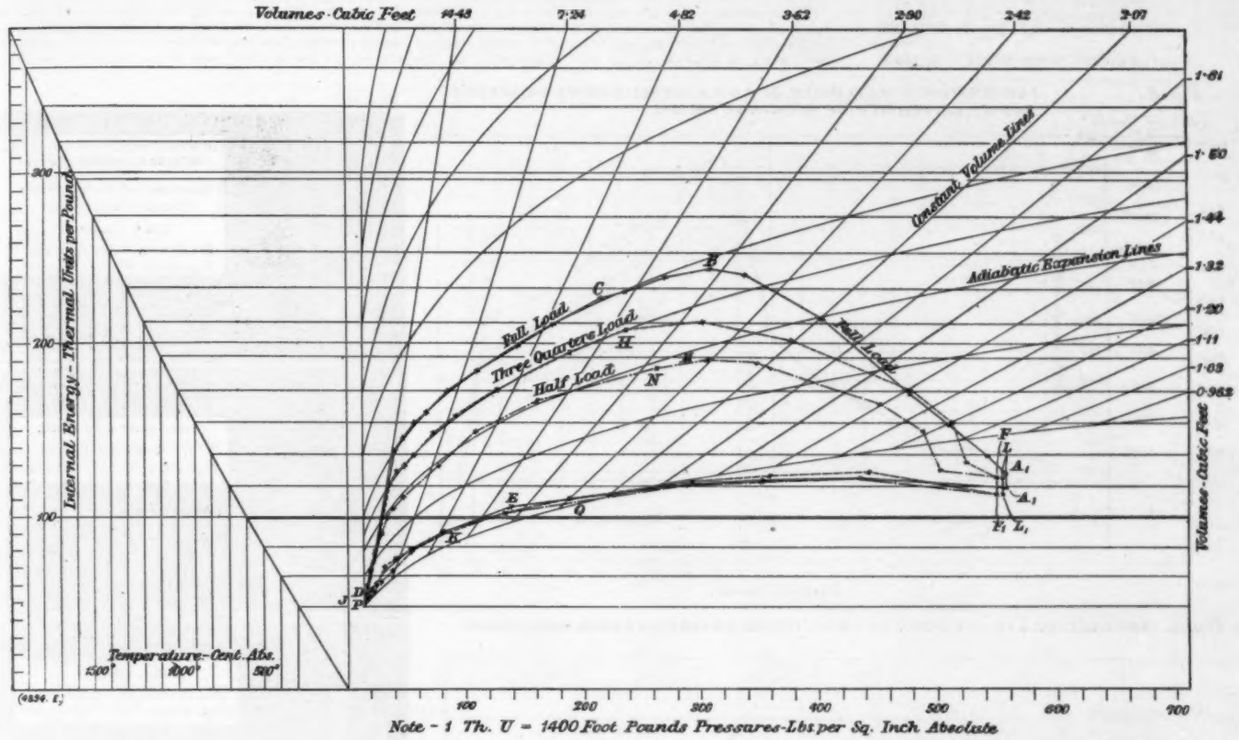
(3) The spring balances were observed, and a constant difference maintained between their readings. No lubricant or cooling medium was used on the flywheel during the test.

The results of tests at full load, three-quarters load and half load are given in Table I. These figures are confirmed by many preliminary experiments.

Commentary on Apparatus and Test Results.—It will be noted that the quantity of air passing through the meter was somewhat in excess of the standardised capacity of that instrument, nevertheless the accuracy of measurement under the conditions given was stated by the makers to be within 0.5 per cent. The figures given for the weight of injection air used are probably not reliable within 5.0 per cent. In these trials the mean jacket temperature was purposely kept approximately the same, in order to keep the cylinder charge-weight as constant as possible. The diminution in charge-volume with increasing load is then due mainly to the higher temperatures of the cylinder wall at the larger loads.

Indicator Diagrams.—A reference to the tops of the mean indicator-diagrams, Figs. 3–5, shows pronounced differences at each load. The manner in which the spraying of the fuel affects the efficiency is shown at half load, where it is apparent that the lower end of the spray-valve is not completely filled by the charge of fuel oil. It will be noticed that an appreciable time elapses before oil is blown into the cylinder and combustion begins. This is shown clearly on the energy diagram. With increasing loads, since there is more oil in the fuel-valve, combustion begins earlier. Under these conditions more oil is being injected than can be burnt immediately, and, as a result, after-burning takes place to a marked extent. At full load the combustion continues down the length of the stroke, whilst at three-quarter load the expansion more nearly approaches the adiabatic.

Fig. 7. ENERGY DIAGRAM



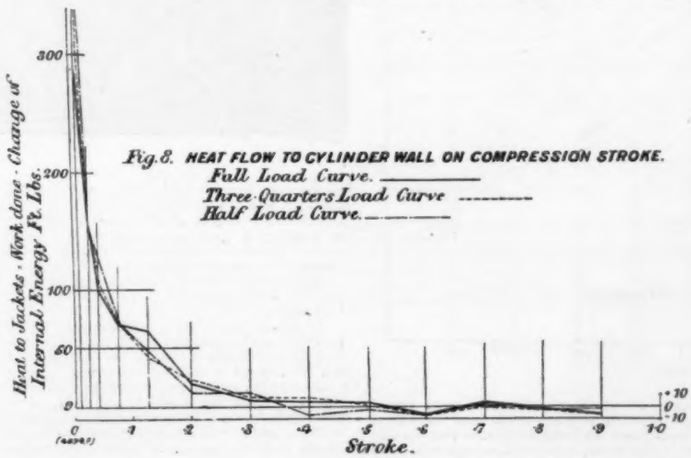


Fig. 8. HEAT FLOW TO CYLINDER WALL ON COMPRESSION STROKE.
Full Load Curve. _____
Three-Quarters Load Curve - - - - - -
Half Load Curve. _ _ _ _ _

TABLE II.—*Figures Deduced from Test Results.*

Units.	Half Load.	Three-quarters Load.	Full Load.
Indicated h.p.	6.81	8.61	10.42
Brake h.p.	3.89	5.73	7.57
Lost h.p. by diff.	2.92	2.88	2.85
Mechl. effy. .. Per cent.	57.1	66.55	72.7
Heat supplied .. ,,	100	100	100
,, as i.h.p. .. ,,	44.6	43.9	42.1
,, to cooling water ,,	32.2	29.2	29.6
,, exhaust by diff. ,,	23.2	26.0	28.3
,, as brake work ,,	25.5	29.2	30.6
,, as friction .. ,,	19.1	14.7	11.5
Main air charge Cu. ft. per cycle	0.1818	0.1805	0.1802
Oil per b.h.p. hr... .. Lb.	—	—	0.448

Energy Diagram.

THE DIESEL CYCLE ON THE ENERGY DIAGRAM.

General Remarks.—A short account of the construction and use of the energy diagram is given in Professor Burstall's paper.* This paper includes an examination of the characteristics of the theoretical Diesel cycle when drawn on the energy diagram. In the present paper the author considers the practical case only of the transference of actual indicator cards from an engine cylinder to the energy diagram. To effect this transference the following information is necessary: the amount of the charge weight and any two of the following four quantities, namely, pressure, volume, temperature, and internal energy. The charge-weight is measured during the tests; pressure and volume are deduced from the indicator cards. The charge quantities measured in the trials are, however, composed of several elements, whilst the energy diagram is drawn for 1 lb. of nitrogen. The charge quantity obtained on test must therefore be adjusted to obtain a weight of nitrogen whose internal energy changes will correspond to those of the substances in the engine cylinder.

The volume of this equivalent charge-weight multiplied by the reciprocal of its weight will give the volume occupied by 1 lb. of nitrogen at the given pressure. It is thus possible to take a series of representative points on the indicator card, to transfer them to the energy diagram, and to determine readily the changes in internal energy and temperature during the compression and expansion strokes. To explain the method more in detail, a representative point will be taken on the expansion line of the full load mean diagram.

Detailed Method of Transference.—The weight of nitrogen equivalent to the charge-weight of air is determined from the fact that for such gases as oxygen, nitrogen and air the product of specific heat and molecular weight is constant—that is:—

$$\frac{\text{Molecular weight of nitrogen}}{\text{Molecular weight of air}} = \frac{28}{28.84} = \frac{\text{specific heat of air}}{\text{specific heat of nitrogen}}$$

The weight of air drawn into the cylinder during the full-load trial = 0.01376 lb.

* The Energy Diagram for Gas, Proceedings, I.Mech.E., 1911, page 171.

∴ equivalent charge-weight calculated to nitrogen

$$= 0.01376 \times \frac{28}{28.84}$$
$$= 0.013358 \text{ lb.}$$

On the working stroke when the fuel valve is closed there are added small quantities of injection air and fuel oil. The weights of these are as follow :—

Oil	... ...	0.0004155 lb.
Air	... ...	0.000629 lb.

and are corrected to nitrogen in the same way as the air charge, thereby making of the full charge a nitrogen equivalent :—

		Lb.
Fuel oil	Carbon	0,000824
	Hydrogen	0.000872
	Injection air	0.000611
	Air charge	0.013358
Total equivalent charge-weight =		0.015665

The internal energy of the actual contents of the cylinder will be

$$= 0.015665 \times 239.5$$
$$= 3.752 \text{ thermal units,}$$

or

$$= 5,253 \text{ ft.-lb.}$$

By this method points have been transferred throughout the expansion and compression strokes, and the result of joining up these points on the energy diagram furnishes a redrawn indicator card, from which the following deductions may be made.

Deductions from the Study of the Energy Diagram.

Deductions from redrawn Indicator Card.—To render the redrawn diagram quite clear, the two diagrams are shown side by side, Fig. 6, and each is numbered at the beginning and end of each operation in the cycle.

To investigate the manner in which heat transfer takes place on the expansion, it is instructive to divide up the stroke into periods, and to measure on the diagram the values of internal energy and temperature at the beginning and end of these arbitrarily fixed periods. The positions of such turning-points are as follows : (1) At top dead-centre with the fuel valve just opening ; (2) the point at which rise in internal energy would seem to have ceased and (3) where expansion commences to follow the adiabatic law ; and (4) that point in the cycle where all the output of energy ceases and a new cycle commences.

Taking the full-load expansion stroke, it will be seen in the first section AB on the diagram, Fig. 7, that 0.60 thermal unit is unaccounted for, or, rather, has either remained in the cylinder in the form of unconsumed fuel after the fuel valve has closed, or else has passed out to the cooling water. It is probable that the greater part of this heat has been imparted to the cylinder wall, as in the next short section, BC 0.107, an additional thermal unit is required to make up the work to be performed by the piston. The work output during the successive periods of the stroke is determined by dividing up the original indicator diagram by perpendiculars and planimetering the area lying between the expansion or compression lines and the line of zero pressure absolute. In the last section, CD, the expansion is practically adiabatic, the work to be done by the piston almost equalling the fall in internal energy, whilst a negligible amount of heat is supplied to the jackets. By arranging these figures suitably it is possible to obtain the total heat-loss to the jackets during expansion and also the loss of heat to the exhaust.

The same process is followed for the three-quarter and half-load expansions, and the results are given in Table III.

The compression strokes are treated in the same manner. In this case the turning-point is taken at the place where the compression line makes a decided deviation from the adiabatic. Reference to the position of this point on the original indicator diagram shows it to be within 15 per cent. of the end of the stroke. It will be noted that the heat lost to the cylinder wall during compression takes place entirely at the top of the stroke. This is also the case during the expansion stroke, and indicates that the heat given to the cylinder liner for the major portion of its length is derived by conduction from the top of the cylinder, and in an engine of the trunk-piston type from the side thrust of the piston upon the cylinder wall. This effect is shown very decidedly by the curves in Fig. 8, which show the rate at which heat is transferred from the charge to the jacket and *vice versa*. These curves are drawn from the information obtained by finding the changes of internal energy and work done over small fractions ($\frac{1}{10}$) of the stroke and plotting these changes in the position in the stroke where they occur.

At present the opinion would appear to be that after-burning usually persists right down the expansion stroke. The figures obtained from these diagrams show that at full load there is distinct after-burning in the second quarter of the stroke, but that in the last part more heat is passing from the charge to the walls than is supplied by after-burning. At half load the heat which has gone to the cylinder wall, when the piston is at the top of its stroke, is almost all repaid half-way down the expansion stroke.

Variation of Temperature in the Engine Cylinder.—Temperature curves, Figs. 9 and 10, have also been drawn both on stroke and on crank-axle or time bases. These curves and the original compression curve on the energy diagram indicate clearly the small rise of the temperature of the charge with this diameter cylinder when the pressure on the compression stroke exceeds 300 lb. per square inch. Towards the end of compression the temperature appears to be constant for a short time, and finally to fall slightly. This fall is shown clearly, and may be due either to the large surface and relatively small volume of the gases at top dead-centre, or to the cooling effect of a spray of cold injection air coming in when the fuel valve is opening.

Volumetric Efficiency.—The volumetric efficiencies are worked out upon volumes of air taken at 760 mm. pressure. It will be noticed that they are high, and that the temperatures necessary to fill the cylinder are low.

Turning now to the mean indicator diagram for the full-load tests, Fig. 3, page 422, a point is taken where the piston is at 0.15 of its stroke, the pressure in the cylinder is 337.7 lb. per square inch, and the charge occupies 0.042485 cub. ft.

The volume occupied by 1 lb. of nitrogen under the given conditions

$$= 0.042485 \times \frac{1}{0.015665}$$
$$= 2.718 \text{ cub. ft.}$$

On the diagram a perpendicular is erected from the point on the pressure scale corresponding to 337.7 lb. The intersection of this perpendicular with the constant volume line for 2.718 ft. gives, when referred to other scales, the magnitudes of the internal energy and temperature of the cylinder charge.

To obtain the numerical value of the internal energy the value given on the diagram must be multiplied by the weight of the charge. For the point under consideration the values are :—

Temperature = 1,335 deg. C. absolute.
Internal energy = 239.5 deg. C. thermal units per lb.

Fig. 9. TEMPERATURES IN CYLINDER OF 8 B.H.P. DIESEL ENGINE ON STROKE BASIS. UNIVERSITY OF BIRMINGHAM, 1913.

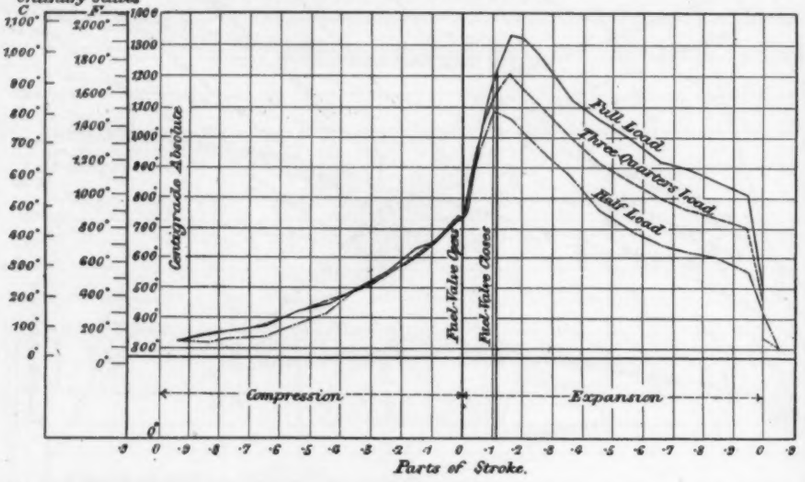


Fig. 10. TEMPERATURES IN CYLINDER OF 8 B.H.P. DIESEL ENGINE ON CRANK ANGLE BASIS.

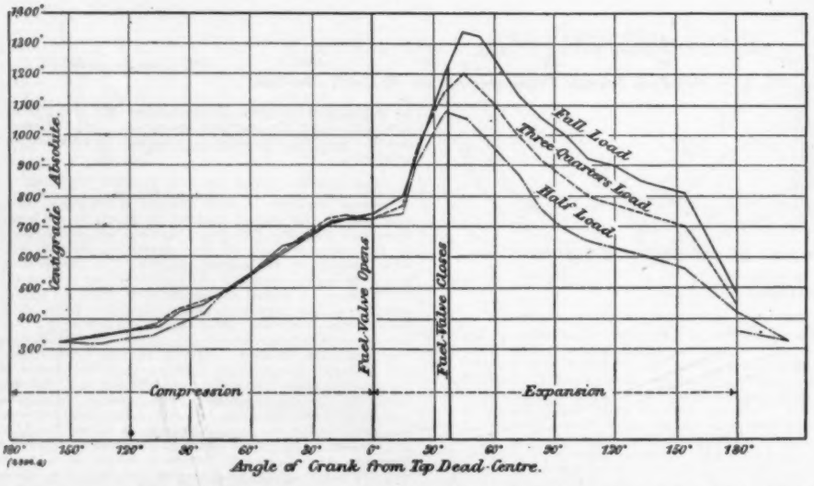


Fig. 11.

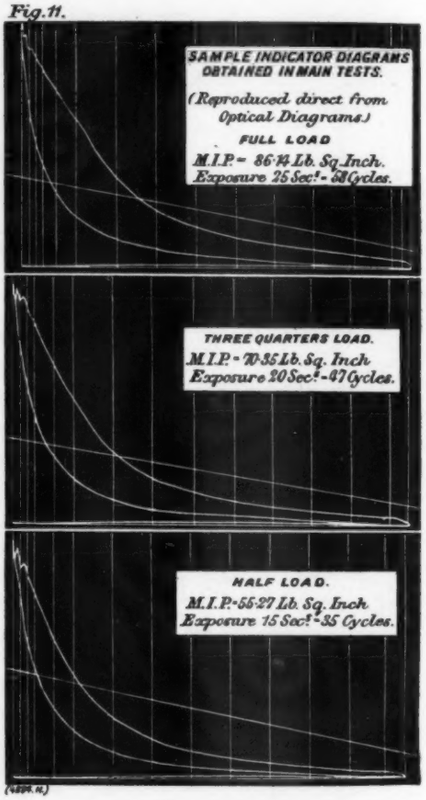

SAMPLE INDICATOR DIAGRAMS OBTAINED IN MAIN TESTS.
(Reproduced direct from Optical Diagrams.)
FULL LOAD
M.I.P. = 86·14 Lb. Sq. Inch.
Exposure 25 Sec.! - 58 Cycles.
THREE QUARTERS LOAD.
M.I.P. = 70·35 Lb. Sq. Inch
Exposure 20 Sec.! - 47 Cycles.
HALF LOAD.
M.I.P. = 55·27 Lb. Sq. Inch
Exposure 15 Sec.! - 35 Cycles.

TABLE III.—HEAT-FLOW DURING EXPANSION.

	Description.	Derivation.	Full-Load Trial.			Three-quarters Load Trial.			Half-Load Trial			
	Period ..		1 AB	2 BC	3 CD	1 FG	2 GH	3 HJ	1 LM	2 MN	3 NO	4 OP
1	Internal energy of charge at start	Energy diagram	1.70	3.81	3.52	1.62	3.20	2.98	1.64	2.89	2.82	2.53
2	Internal energy of charge at finish	Energy diagram	3.81	3.52	2.08	3.20	2.98	1.75	2.89	2.82	2.53	1.44
3	Heat supply	Fuel Measurement	4.3	—	—	3.36	—	—	2.62	—	—	—
4	Change in internal energy ..	(2) − (1)	2.11	0.29	1.44	1.58	0.22	1.24	1.25	0.07	0.29	1.09
5	Work done on piston	Indicator card	1.59	0.39	1.40	1.62	0.23	1.20	1.21	0.16	0.43	0.99
6	Total internal energy change ..	(4) + (5)	3.70	—	—	3.20	—	—	2.46	—	—	—
7	Heat unaccounted for (unburnt fuel; loss to jackets)	3 − (4) + (5)	0.60	—	0.04	0.16	—	0.04	0.16	—	—	0.10
8	Heat unaccounted for (unburnt fuel; from jackets)	—	—	0.10	—	—	0.10	—	—	0.08	0.14	—
9	Total loss to jackets on cycle ..	7 − 8	—	—	0.54	—	—	0.19	—	—	—	0.04
10	Exhaust	Diagram	—	—	1.38	—	—	1.04	—	—	—	0.94

TABLE IV.—HEAT-FLOW DURING COMPRESSION.

	Description.	Derivation.	Full-Load Trial.		Three-quarters Load Trial.		Half-Load Trial.	
	Period ..		1 DE	2 EA	1 JK	2 KF	1 PQ	2 QL
1	Internal energy at start	Energy diagram	0.70	1.63	0.70	1.68	0.70	1.64
2	Internal energy at finish	Energy diagram	1.63	1.64	1.68	1.625	1.64	1.69
3	Change in internal energy ..	(2) − (1)	0.93	0.01	0.98	0.055	0.94	0.05
4	Work done by piston	Indicator diagram	0.87	0.66	0.90	0.67	0.83	0.72
5	Gain from jackets	(3) − (4)	0.06	—	0.08	—	0.11	—
6	Loss to jackets	(4) − (3)	—	0.65	—	0.72	—	0.67
7	Total loss of internal energy ..	(6) − (5)	—	0.59	—	0.64	—	0.56

TABLE V.—VOLUMETRIC EFFICIENCY AND CHARGE QUANTITIES.

Description.	Units.	Half Load.	Three-quarters Load.	Full Load.
Meter reading corrected to 60 deg. F. and 760 mm. ..	Cub. ft. per hr.	1510	1490	1470
Volume of charge per cycle	Cub. ft.	0.1818	0.1805	0.1802
Weight of air charge per hour	Lb. per hr.	112.27	113.72	115.42
,, ,, cycle	,,	0.01383	0.01378	0.01376
Volumetric efficiency on total vol. of cyl.	Per cent.	84.2	83.7	83.6
,, ,, inlet valve closing	,,	87.1	86.55	86.4
Temperature at end of suction (on piston sweep)	Deg. C. abs.	324	325	326
Injection air per hour	Lb. per hr.	6.86	6.5	5.13
,, ,, cycle	Lb.	0.000825	0.000788	0.000629
Oil	Lb. per hr.	2.093	2.686	3.389
Oil, weight per cycle	Lb.	0.00025124	0.0003255	0.0004155
Hydrogen, weight per cycle	,,	0.00003768	0.00004882	0.00006232
Carbon, weight per cycle	,,	0.0002135	0.0002766	0.0003531
Equivalent charge-weights—				
Air charge per cycle	,,	0.013476	0.013378	0.013358
Injection air per cycle	,,	0.0008009	0.000765	0.0006106
Carbon per cycle	,,	0.000498	0.000645	0.000824
Hydrogen per cycle	,,	0.0005276	0.0006835	0.0008725
Total charge-weight per cycle	,,	0.015303	0.015472	0.015665

NOTE TO TABLE V.

Total vol. of cylinder	0.2158	cub. ft
,, ,, when inlet valve closes	0.2083	,,
Volume of clearance	0.0199	,,
,, piston sweep	0.2039	,,

TABLE VI.—*Determination of True Percentage Heat Balance-Sheet.*

—	Half Load.	Three-quarters Load.	Full Load.
	Quantities in foot-pounds.		
Work area under expansion curve	3901	4264.6	4728.6
Work area under compression curve	2151.05	2195.1	2170.7
(A) Useful work per cycle ..	1749.95	2069.5	2557.9
Heat to jackets on expansion	46.76	273.98	753.76
Heat to jackets on compression	832.02	907.3	768.04
(B) Total heat to jackets ..	878.8	1181.3	1521.8
(C) Total heat to exhaust ..	1036	1460.2	1939.7
Total heat per cycle (A + B + C)	3664.7	4711	6019.4

TABLE VII.—*Amount of Heat Extracted from Exhaust Gases by Cylinder Cover.*

—	Half Load.	Three-quarters Load.	Full Load.
Heat of jackets (Diagram) ft.-lb.	878.8	1181.3	1521.8
,, ,, (Trials by diff.) ft.-lb.	1173	1375	1781
Difference .. .. ft.-lb.	157.2	193.7	259.2
Percentage amount .. ft.-lb.	13.4	14.1	14.5

The correction for hot residuals will therefore be small enough to be negligible. A general check on the temperature figures is given by the comparisons of the thermal efficiencies obtained directly and by means of the energy diagram.

Determination of True Percentage Balance-Sheet.—By combining the figures obtained from the indicator and energy diagrams, the true percentage heat balance-sheet may be obtained and compared with the apparent balance-sheet obtained directly from the test results. The procedure followed in working out the figures is self-explanatory from the tables.

TABLE VIII.—*Heat-Flow during Compression.*

—	Half Load.	Three-quarters Load.	Full Load.
Loss to jackets .. .. ft.-lb.	832	907	768
Work done on compression ft.-lb.	2151	2195	2170.7
Percentage lost work .. ft.-lb.	38.7	41.3	35.4

From the figures in lines A B C the true percentage heat balance-sheet can be determined :—

—	Half Load.		Three-quarters Load.		Full Load.	
	Energy Diagram.	Test Results.	Energy Diagram.	Test Results.	Energy Diagram.	Test Results.
Thermal efficiency ..	47.7	44.5	44.0	43.8	42.5	42.1
Heat to jackets ..	24.0	32.2	25.1	29.2	25.3	29.6
Heat to exhaust ..	28.3	23.3	30.9	27.0	32.2	28.3
Totals ,, ..	100.0	100.0	100.0	100.0	100.0	100.0

Attention is directed to the discrepancies between the figures obtained by each method for the value of the percentage indicated thermal efficiency. The differences provide an indication of the accuracy with which the measurements and graphical operations were carried out.

The differences at the same load in the percentage amount of heat going to the jackets in Table VI are, of course, due to the fact that the cooling water extracts a large amount of heat from the exhaust gases on the exhaust stroke, as these gases, besides flowing round the exhaust valve, are directed to the outlet round a right-angled bend in the cover. The numerical values of these figures are determined, and attention is directed to the fact that the amount of heat extracted by the cooling water from the exhaust gases, expressed as a percentage of the total heat given to the cooling water, is remarkably constant.

Heat-Flow during Compression.—It will be seen in Table VIII that the figures for the heat-losses to the jackets are quite irregular, but, as may be supposed, the heat-loss at full load is appreciably less than at other loads.

The author desires to express his thanks to Professor Burstall and Dr. Fisher, of the University of Birmingham, for the facilities afforded and suggestions given; to Professor Watson, of the College of Science, for the gift of two of his own diaphragms, which proved of great use in the preliminary investigations in connection with the manufacture of the diaphragms for use in the indicator; and to his fellow research-student, Mr. A. U. Zimmerman, and the staff of the university for their practical assistance.

NEW METHOD FOR EXPLOITING POOR IRON ORE.—A company has been formed in Norway for the exploitation of a new method applicable to ores poor in iron, invented by the well-known Swedish inventor, Dr. Gustaf Gröndal, and two Norwegian engineers. The capital is 900,000 kr., and temporary experimental works will be started in a Swedish mining district, but the practical exploitation will take place in Norway, where water power, of which a considerable quantity is needed, is cheaper than in Sweden, and where there are large deposits of the ores in question.

GERMAN AFRICAN RAILWAYS.—According to official reports, the German railways in Africa at the end of 1913 had an aggregate length of 3,754 kilometres. The following table gives particulars as to the railways of the different colonies and their working during the year 1913 :—

—	Trafficked Distance in Kilometres.	Gross Receipts in Marks.	Working Surplus in Marks.
East Africa	1,200	5,390,765	2,035,674
Togo	330	1,152,551	500,986
South-West Africa	1,914	9,241,373	3,946,777
Kameroun	310	1,187,818	433,530
	3,754	16,972,507	6,916,967
The corresponding figures for 1912 were	3,416	15,870,625	5,725,886

The surplus averaged in 1912 1,676 marks per kilometre (135*l.* per mile), against 1,845 marks per kilometre (148*l.* per mile) in 1913. The surplus, however, varied greatly for the different railways, from 144 marks to 4,412 marks per kilometre (350*l.* per mile), the latter figure referring to the Otavi railway, 671 kilometres long, in South-West Africa.

THE GERMAN ALKALI INDUSTRY.—Particulars now available about the doings of the alkali syndicate during 1915 show how seriously they have been interfered with by the war, more especially as regards the foreign trade. The sales in double centners were :—

	Inland.	Abroad.
1910	4,190,000	4,390,000
1911	4,800,000	4,600,000
1912	5,290,000	4,810,000
1913	6,040,000	5,060,000
1914	5,380,000	3,660,000
1915	5,670,000	1,130,000

With the exception of Luxemburg, the sale to all foreign countries showed a decrease during last year, as will appear from the subjoined table :—

	1914.	1915.
Austria-Hungary	268,415	230,561
Switzerland	42,841	25,394
Belgium	114,806	106,594
Holland	424,151	392,954
Scandinavia	392,146	366,096
Russian Poland	74,565	16,542
United States and Hawaii ..	1,623,728	53,740

During the year 1913 the export to the United States, including Hawaii, amounted to 2,482,948 double centners (100 kilogrammes). The sales of the various kali (potash) and magnesia products (in K_2O double centners) were as under :—

	1913.	1914.	1915.
Carnallite and rock kieserite	68,075	48,742	37,384
Kainite and sylvanite ..	3,227,209	2,558,904	2,489,002
Kali manure salts—			
Not less than 20 per cent.	481,122	336,966	158,650
,, ,, 30 ,,	192,848	144,632	65,955
,, ,, 40 ,,	2,459,703	2,611,001	2,880,705
Kali (potash) manure ..	191,495	227,065	259,037
Chloride of potassium ..	2,448,505	1,536,896	679,866
Sulphate of potash	539,236	370,412	26,121
Sulphate, kallmonuria ..	151,265	142,311	200,743
Sulphate, crystallised ..	258	335	300
Kieserite—			
In blocks (actual weight)	367,082	179,512	39,487
Calcined ,,	11,658	10,596	10,412

The report points out that the embargo had had a distressing effect upon the export, but whilst the export essentially decreased the home sale had somewhat improved. Owing to the great shortage of nitrogen and phosphorus manures, the sale of alkali manures was bound to increase on the home market.

PRESIDENTIAL ADDRESS TO THE INSTITUTION OF MECHANICAL ENGINEERS.*

By the President—W. Cawthorne Unwin, LL.D., F.R.S.

It has not been usual for the president to make a formal address at the opening of the session in his second year of office. I do not know whether this is due to consideration for the president or is a measure of relief to members. In normal times I should not have departed from precedent. But with your acquiescence I should like to make a short statement, partly to explain the position of the Institution, partly to expand a point in my address a year ago. I recognise that a statement by the president is not discussed, and that his views, if erroneous, do not commit the Institution. He is the more bound to be careful and moderate.

The conditions of the time have unavoidably restricted some of the activities of the Institution. We have placed our building at the disposal of the Government, and there is no immediate prospect of regaining the use of it. Happily, through the kindness of the Institution of Civil Engineers, who permit to us the use of their meeting hall and library, the inconvenience to our members has been much diminished.

It is a difficulty that six members of the office staff of the Institution have been called up for active service, and it is inconvenient to the secretary to carry on the considerable business of the office with untrained assistants. Nevertheless, so far the meetings have been held regularly; several provincial meetings have been held, and the Journal has been issued as usual.

The Council decided that it was impracticable to hold the summer meeting, the conversazione, or the annual dinner when so many members were absorbed in war work. In this they have taken the same course as other scientific societies.

The number of candidates for election does not seem to have been much affected by the war. Taking the first six months of the year, the number elected was 129 in 1914, 100 in 1915, and 112 this year. Somewhat fewer candidates have presented themselves for examination.

Nearly 900 members of the Institution are known to be on active service, and many others are engaged on munition or other war work. Unhappily, so far as is known, 29 have died on service and 30 or probably more have been wounded. Our sincere sympathy goes out to their friends in their bereavement. They have died in a great cause and in the service of the country in its extreme need. So far as we know, 15 members on active service have been decorated and eight mentioned in despatches.

It would not be right to pass over, without an expression of our deep sorrow, the deaths of Sir H. Frederick Donaldson, K.C.B., a past-president, and of Mr. Leslie S. Robertson, so long the secretary of the Engineering Standards Committee. They were lost in the disaster to H.M.S. Hampshire, when accompanying Lord Kitchener on a mission to Russia.

There has been rather more difficulty than usual in obtaining papers for the present session; but I trust we may have no mishap. We have tried to obtain a paper dealing with the work of women in munition factories, but so far have not succeeded. It is believed that their services have been invaluable, and that for such work as they can undertake they are little inferior to male workers, either as regards quantity or quality. We hope to have one or more papers on the special machinery for shell manufacture; also shortly a report from the Hardness Tests Research Committee.

In my address a year ago I urged that the rapid economic progress of Germany since the war of 1870, and chiefly in the last 25 years, should be very carefully considered. Relatively, Germany has progressed in many industries much faster than we have. If we are to recover our position, as I believe we may do in the new conditions after the war, it is necessary we should study accurately the facts and causes of German expansion. No doubt that expansion has been too rapid to be healthy, and seems to have induced a feverish sense of insecurity, so that under whatever inspiration the war began, it is certain that commercial and industrial necessities and ambitions had a large place. As an example which appeared to me remarkable, though it is only one of several, I referred to the iron and steel industry, in which not so long ago we were supreme, but in which we now hold third place, and not a good one at that.

In a quarter of a century the production of pig-iron in Germany has trebled and that of steel has sextupled. In 1913 Germany produced 18,000,000 tons of steel, and we produced 7,000,000 tons. It is quite true that nations must depend on each other for products which each is best able to manufacture; but this hardly applies to the iron and steel industry. We have not been wanting in metallurgical knowledge nor obviously worse off in natural resources. Hence the rapid increase and present magnitude of the German production of iron and steel seems to me to have a lesson for us. German trade is conducted as thoroughly and unscrupulously as a warfare, and it may well be that the fostering of the iron and steel industry is amongst the preparations for war, for without a great capacity for iron and steel production the present war could not be prosecuted.

It is impossible to ignore the ambition frankly stated by Dr. Ostwald, the distinguished Leipzig professor, that Germany "having become the military centre of Europe, it was necessary for her to become the industrial centre also."

In a very interesting address to the Royal Society of Arts, Dr. Dugald Clerk made a protest against the tendency to contrast unfavourably British achievements in science and industry compared with those of Germany. With most of this address I heartily agree, and in any case I should differ from Dr. Dugald Clerk with reluctance and even with some trepidation. Many years ago, Walter Bagehot wrote, "We English are always grumbling at ourselves. But, after all, England is a success in the world; her career has had many faults, but it has been a fine and winning career on the whole."

Dr. Dugald Clerk quoted my reference to the iron and steel industry, and replied to it that "it is misleading to cite the relative production of iron and steel as proving either the prosperity of Germany or the decadence of England." As an explanation of the difference in this matter of England and Germany, Dr. Dugald Clerk says that "the United Kingdom has a total of 23,000 miles of railway and Germany has 38,000 miles," and that "it would be extraordinary if a capable and industrious nation, such as the Germans are, could not succeed in making most of the steel required for their own use." But he has forgotten that in India there are 33,000 miles of railway, almost as many as in Germany, mainly built and maintained by the use of English steel, and railways in other colonies naturally supplied from this country. The railway mileage test does not seem to explain the large German production of steel.

Dr. Dugald Clerk says also that the greater part of German steel is used at home. But how far is that true? In 1912 Germany exported a million tons of pig-iron and 4,000,000 tons of steel partly manufactured.* In 1913 we imported from Germany iron and steel to the value of 7,500,000*l.*, and in addition machinery to the value of 2,300,000*l.*† Take a single article, railway rails. Between 1908 and 1912, only four years, the export of rails from the United Kingdom decreased 10 per cent., that from Germany increased 16 per cent., and that from the United States 22 per cent. In 1912 both Germany and the United States exported more rails than we did. Now the iron and steel industry is a basic industry; the prosperity of it affects almost all other industries. We might get on without a dye industry, but the steel industry is vital.

The impulse to the development of the German iron and steel trade came from the acquisition in 1871 of part of Lorraine containing 1,800,000,000 tons of minette iron ore, followed by the discovery in 1877, by Thomas and Gilchrist, of the basic process. Probably Germany expected as one result of the war to annex the still larger iron deposits in the part of France now occupied by her armies. Mr. Ellis Barker has stated that the attack on Verdun was probably due to the wish to deprive France of her iron ore. It is probably true that steel is produced in Germany more cheaply than here. The works are on a very great scale and under the most able commercial and scientific management. German steel is almost exclusively made by the basic process. British steel is made chiefly by the acid process, which requires purer ore, and in fact a large part of our production is from imported ore. I believe we could produce more basic steel, and it is worth consideration whether a prejudice against basic steel justified in early days is now reasonable.

An influence which in the opinion of Continental economists has been powerful in the development of German trade, is the system of Kartells which have been formed since the passing of rigidly protective legislation in 1879. One of them, the Steel Union, embraces 31 firms with an annual output of 12,000,000 tons. Based on mutual consent, it controls the selling price of steel in each district, the area within which each selling agency may supply, the total annual output of each steel works, and the allocation among makers of the profits. It was ostensibly the object of this combination to reduce cost of production by regulating output and abolishing competition between firms in the syndicate. No doubt a less openly confessed object was to acquire selling monopolies and impose its own price on consumers.

It is alleged that the Steel Union systematically resorts to dumping. In normal trade the price increases with the distance from the centre of production, being loaded with transport and other charges. In dumping the reverse is the case, out of profits made in a protected home market, bounties are given on exports to vanquish competition. For instance, from figures given by M. Milliond, girders and rolled bars sold in Germany at 130 marks were sold in England and South America at 103 to 110 marks, and in Italy, where it was desired to hamper a struggling industry, at 75 marks. Sir Robert Hadfield has stated that before the war the export bounty granted by the Steel Union amounted to 15 marks per ton. The sale at a low price of an accidental surplus due to over-production is one thing; deliberate over-production in order to defeat competition abroad by dumping is another. Competent observers like M. Milliond believe that that has been the policy of the Steel Union.

Perhaps there is nothing illegal or which contravenes ordinary trade morality in a system of dumping. The Commissioner sent by *The Times*, in 1901, to report on "American Competition," states that American manufacturers openly avowed the intention to keep up prices by stinting the home market in order to force the export trade by cutting prices in foreign countries. Possibly the importance of dumping may have been overrated. Continental economists do not seem to think so. But I do not believe that any nation subjected to systematic dumping will permanently submit to strangulation by an unfair trade method. It is not for me to suggest a remedy. No doubt one can be found, and personally I hope it may not interfere with our custom of unrestricted trade.

To adopt a Kartell system with the protection which is its basis in Germany, would be contrary to our ideas and traditions. But dumping is not an essential part of association in trade. We may recognise that as Naumann says, in Mittel-Europa, "combination means the elimination of wasteful competition, economy of large production and gains from expert buying and selling on a large scale." It is a matter for consideration whether our trade methods have not been too individualistic. There would seem to be advantages in co-operation of firms, not merely to control labour, but in introducing methods of workshop organisation, in pooling commercial and technical knowledge, in uniting in scientific investigations, and in establishing competent agencies in foreign countries. The Engineering Standards Committee is an example of advantages obtained by consultation and compromise without interference with individual freedom, and standardisation of production is likely to be much extended after the war.

Mr. Asquith said, "I lay particular emphasis on two tendencies. The first is the development of trade associations for common action at home and abroad, raising the average standard of production. The second is the recognition of the leeway we have to make up as regards scientific research and its application to technical and industrial purposes."

In August, 1914, the navy was ready, but in other respects we were unprepared for the war which was forced on us. But the way in which our characteristic unpreparedness, slackness and inertia have been overcome and organisation created is extraordinary. It is an engineers' war, and mechanical engineers can realise the task involved in their department. Four thousand factories are under Government control, and the private workshops have been organised under local committees and adapted to unaccustomed work of great precision. In Mr. Asquith's words, "the history of the war in the industrial sphere at home has been a history of grave and threatening difficulties, courageously faced and successfully overcome." In spite of the withdrawal of men for the front and the employment of a million and a half of men and nearly half a million women on munition and war work, ordinary activities have been kept going without serious embarrassment. But when the war is over there lies ahead another strenuous time. There will be the cessation of war expenditure, the return of the men at the front with physical and mental capacity enlarged by the experience and discipline of service, and the disposal of the women who, in munition factories and elsewhere, have been replacing men and earning unaccustomed wages. Still, there is no reason for pessimism. Our productive output has been enormously increased under war stress, and may be maintained in peace. There has been the creation of very large new engineering factories, older factories have been overhauled and equipped with new high-class tools. Manufacturers have co-operated in a way unknown before, and workshop methods and organisations have been improved. Industry has been modernised and invigorated.

Certainly relations between employers and employed have been unsatisfactory in the past. There are signs that the admirable co-operation which has been exhibited during the war has produced a better feeling. We may hope that with some increase in the rewards and improvements in the condition of workmen, deliberate restriction of output may be abolished. Adopted partly from false economic ideas, partly from natural anxiety as to wages and status as craftsmen, it has been, as Mr. Arthur Chamberlain says, effective, but at a terrible cost in loss of production.

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* Delivered October 20.

* Board of Trade. Iron and Steel, 1912.

† Sir L. G. Chiozza Money, M.P.

Japanese Shipping and South America.—We read in the *London and China Telegraph* that a Japanese commission, representing a group of Japanese capitalists, manufacturers and merchants, is at present in Brazil making a study of the economic and commercial conditions in Rio de Janeiro, Sao Paulo, Parana, Santa Catharina, and Rio Grande do Sul, with a view to the possibility of establishing steamship service between Japan and Brazil *via* Singapore, Ceylon, Madagascar and Cape of Good Hope.

Joint State and Municipal Hydro-Electric Undertaking in Norway.—The question of the Norwegian State and the city of Christiania jointly exploiting the Mörkfos Fall, belonging to the State, and the Solbergfos Fall, belonging to the City of Christiania, has been under discussion for some time, and a special committee, appointed for the purpose, has drawn up a plan for carrying out the scheme. It is proposed to undertake the joint exploitation under a joint board appointed by the two contracting parties. A large dam has to be built at the Solbergfos Fall, which will back up the water as far as the Oieren, the outlet from Oieren taking place at Solbergfos. Each of the contracting parties is to have its share of the power station at its own disposal, the installation of machinery being left to each party, so that they can instal and extend as it may suit them. This arrangement has particularly been made with a view to the State using the Mörkfos power for railway electrification. The method of transmission is left to each party, the actual production of energy only being a joint concern. The joint power station will have a calculated capacity of 50,000 h.p., but if the Glommen is to be further taken into account, the capacity will be further increased. The cost is calculated at about 19,000,000 kronen, of which the State is to defray one-third and the municipality of Christiania two-thirds, the generated power being divided in the same proportion. The work, it is understood, will be pushed ahead rapidly, and the power station is reckoned to be ready in 1920 or 1921. (1 krone = 1*s.* 1½*d.*)